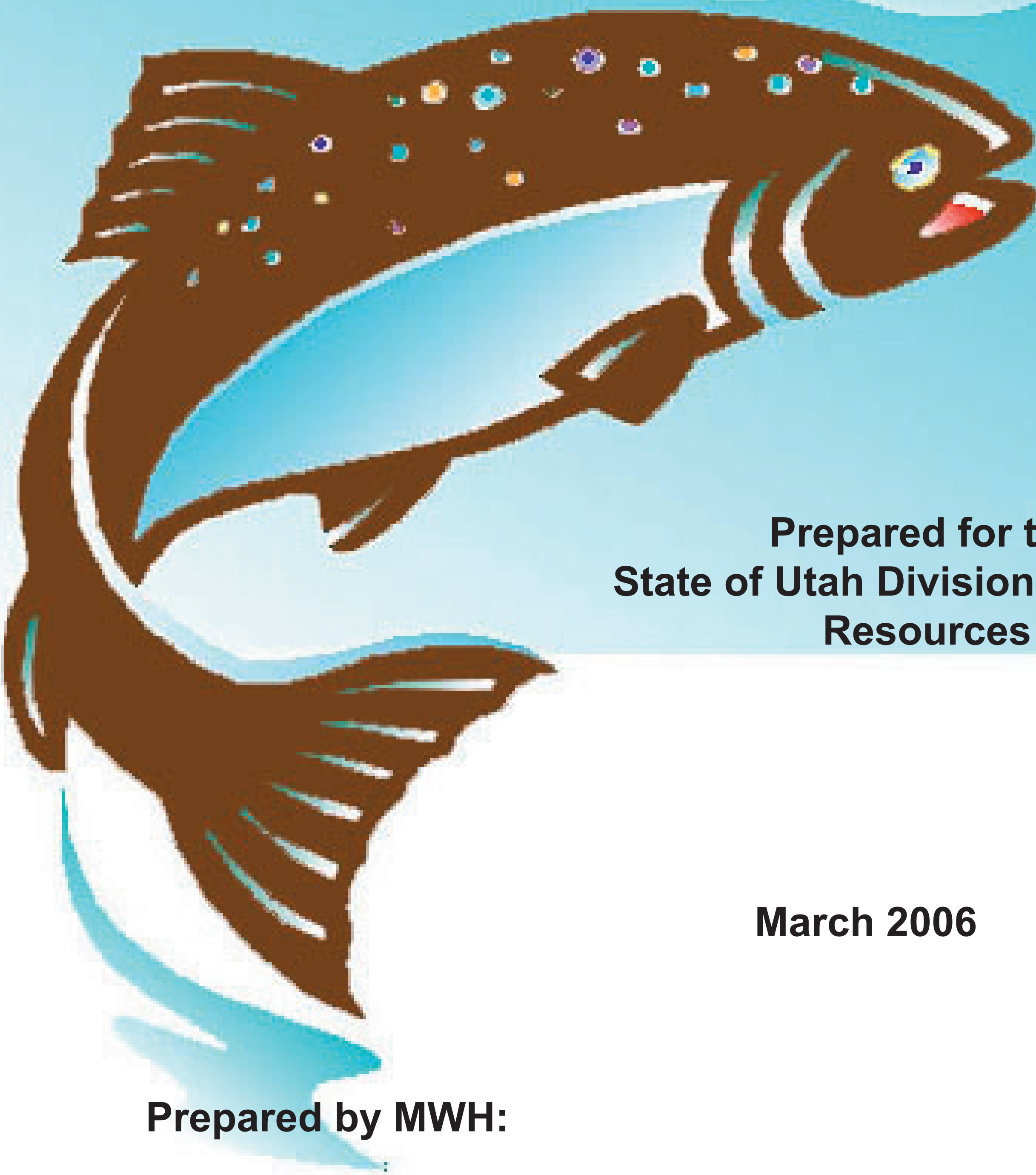
Midway State Fish Hatchery Master Plan



Prepared for the
State of Utah Division of Wildlife
Resources

March 2006

Prepared by MWH:

Salt Lake City, Utah
Boise, Idaho

Midway State Fish Hatchery

Master Plan

Prepared for the
State of Utah Division of Wildlife Resources
Project No. 031-805-20
Contract No. 067192

Prepare by MWH: **Salt Lake City, Utah**
Boise, Idaho

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Section 1

SECTION 1

INTRODUCTION TO FISH CULTURE FACILITIES AND WATER SUPPLY AT THE MIDWAY FISH HATCHERY

1.0 EXISTING FISH CULTURE FACILITIES INTRODUCTION

Midway Fish Hatchery (MFH) is a coldwater hatchery owned by the State of Utah located near the City of Midway, Utah (Figure 1-1).

The purpose of this section is to describe the existing fish culture facilities and the available water supply for meeting the program rearing requirements and the disease issues that prompted the Utah Division of Wildlife Services (DWR) to close the existing hatchery in 2000. The data was developed by MWH Americas, Inc. based upon a site visit, discussions and workshop meetings with the DWR staff and the available information, site records and team observations.

1.1 Water Supply

Springs were the source of all process water used in the Midway Hatchery through 2004. The spring flows were collected in a head box and flowed by gravity into the system from the subsurface collection system. A portion of the spring water entered the hatchery building by gravity flow and the remainder was sent to the raceways and ponds.

Midway Fish Hatchery operated for many years using discharge from the shallow spring at the north end of the hatchery property. However, discovery of *Myxobolus cerbralis*, a parasite that causes whirling disease in trout, resulted in closure of the hatchery in 2000. The three new production wells have been drilled to provide a new disease-free water source from the lower of two confined aquifers that underlie the hatchery.

Both of the confined aquifers have piezometric surfaces above ground level, meaning that the pressure in the aquifers causes flowing artesian conditions in wells open to these aquifers. The level to which water rises in wells open to the lower confined aquifer is higher than the level to which water rises in wells open to the upper confined aquifer, indicating that the hydraulic pressure gradient is upward. This is important, because it means that the natural direction of flow is upward, preventing natural downward movement of contaminants from the shallow water table aquifer into the confined aquifers. The three aquifers are separated by tufa, a calcium carbonate precipitate associated with geothermal discharges common to the Heber Valley. However, water quality conditions and water levels responses in monitoring wells in the three aquifers during pumping tests suggest that there is some hydraulic connection between the three aquifers.

The three flowing artesian wells were drilled and constructed in 2002 by American Well Drilling (Figure 1-2). Well construction information is presented in Table 1-1. Aquifer pumping tests were performed in the wells in 2004 by hydrogeologists from Brigham Young University

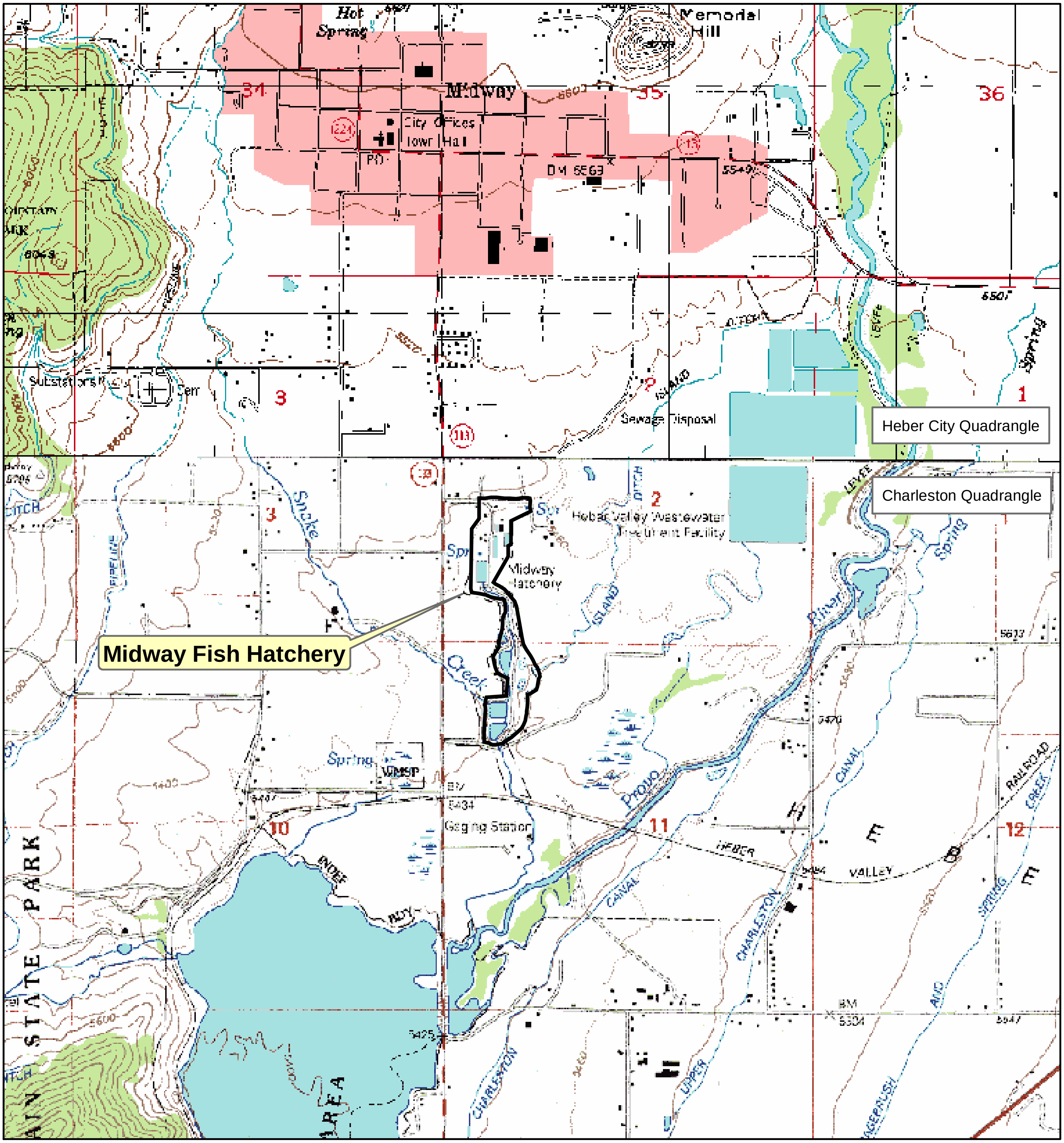
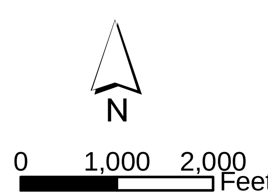


Figure 1-1
Midway Fish Hatchery Location Map



7.5 Minute USGS Quadrangle Charleston
Section 2 and Section 11
T4S, R4E

Latitude 40.495 degrees North
Longitude 111.469 degrees West

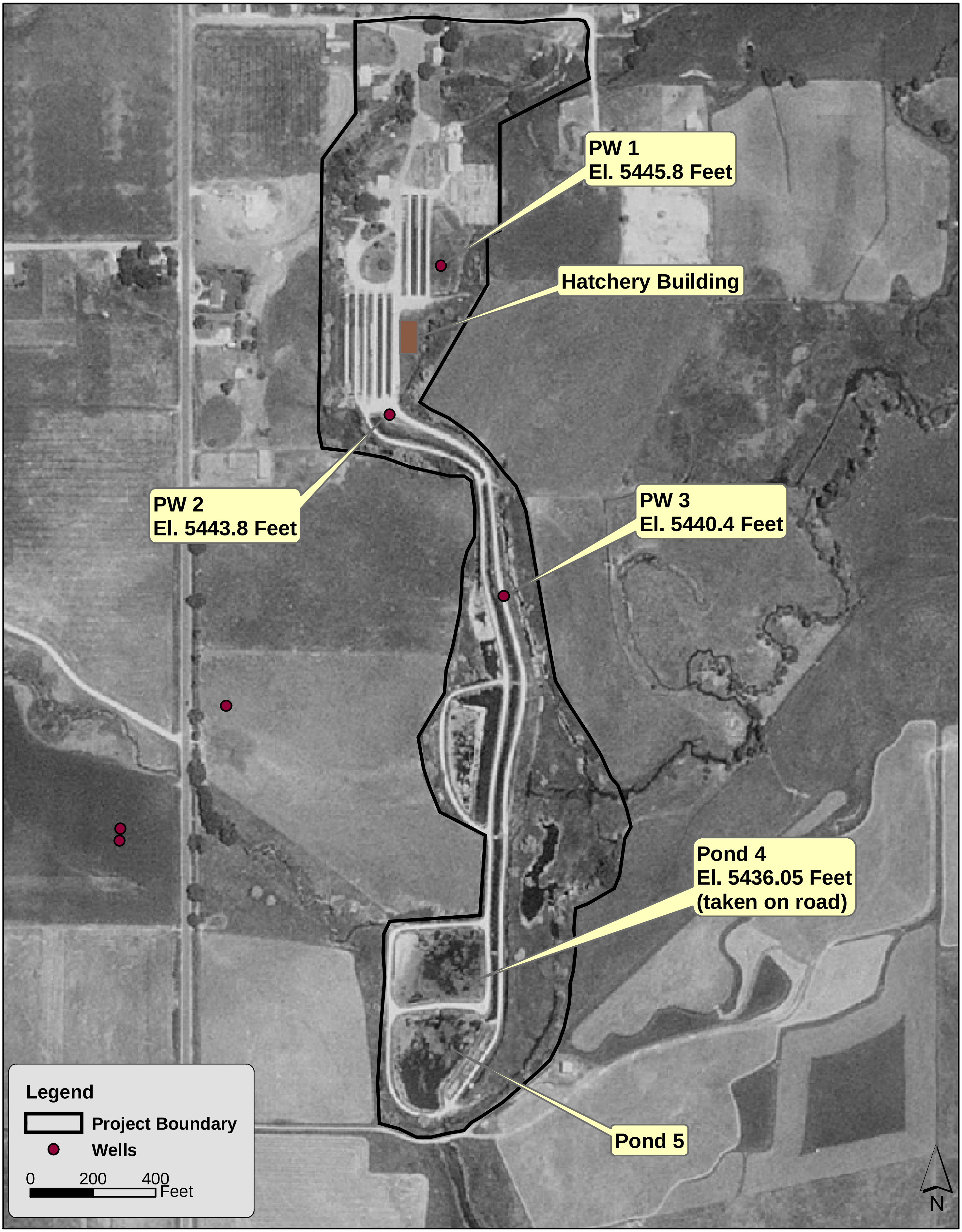


Figure 1-2
Well and Pond Locations and Elevations

(BYU). The results of testing were presented in a masters thesis (Durrant, 2005) and a report (Mayo et al., 2005).

TABLE 1-1

MIDWAY FISH HATCHERY
PRODUCTION WELL INFORMATION

Well Number	Depth (ft)	Inside Casing Diameter (in.)	Open Intervals (ft below ground surface)	Screen Type
PW-1	386	16	170-217, 255-265, 277-345, 360-370	Mills-knife perforated
PW-2	367	16	155-165, 185-210, 225-245, 258-263, 273-335	Shot perforated above 263 ft; 0.040-inch slotted screen 150 ft-335 ft
PW-3	390	16	165-175, 190-205, 220-354	Mills-knife perforated above 230 ft; 0.050-inch slotted screen 173-354 ft

The upward hydraulic gradient indicates that any leakage from one confining layer to the next occurs upward from a lower aquifer (production well source) to the upper shallow aquifer, and presumably cannot go in the other direction. After biologically testing the production zone water and confirming that whirling disease was not evident, the decision was made to proceed to develop a new disease-free hatchery using this supply. Table 1-2 provides a summary of the characteristics for the three production wells. While these can be expected to change somewhat over time as a result of hydrologic and seasonal conditions and surrounding land use and other demands on the aquifer, they represent a stabilized condition at this time.

The production potential from individual wells was previously evaluated by BYU (Mayo et al., 2005). The pumped flowrate from each well determined in the BYU evaluation assumed that the maximum drawdown in each well could not exceed the upper tufa confining layer. This assumption was made to protect against reversal of the upward gradient that is believed to prevent downward migration of contamination into the confined aquifers. The BYU flowrate projections conservatively disregarded the effects of well inefficiency in determining the maximum allowable drawdown in the wells, because of uncertainties in calculating well efficiencies and because no mechanism was in place to measure and verify formation drawdown as opposed to pumped well drawdown (MWH 12/23 Naylor to Midway Fish Hatchery Distribution).

Table 1-3 shows the projected maximum pumping rate allowed in each individual well, as determined by the BYU evaluation. An evaluation of potential pumping rates allowing for well efficiencies (i.e. pumping at the maximum flowrate that would allow drawdown in the pumped wells to exceed the 33-foot depth to the top of the upper confining layer but would not draw the formation water level below the 33-foot depth) results in a theoretical pumping rate of over 4,000 gpm at PW-1 and about 8,000 gpm at PW-2 and PW-3. The well efficiencies used for these projections were selected from a range of calculated efficiencies for each well. In reality, the

TABLE 1-2

PROJECTED CHARACTERISTICS FOR ARTESIAN FLOW AND AVAILABLE HEAD
NO ALLOWANCE FOR WELL EFFICIENCY

Location	Ground Surface Elev. (ft)	Elev. Above Pond 4 (ft)	Artesian Head (ft. AGL)	Artesian Head Date	Piezometric Surface Elev. (ft)	Piezometric Surface Head Above Pond 4 (ft)	Approx. Distance from Pond 4 (ft)	Approx. Pipe Friction Headloss (ft) [(a)]	Available Artesian Drawdown (ft) [(b)]	Specific Capacity (gpm/ft)	Estimated Artesian flow (gpm) [(e)]	Total Interference (ft) [(f)]	Degassing Tower Headloss (ft) [(f)]	Net Head (ft) [(g)]
PW-1	5445.8	9.7	7.8	8/30/04	5453.6	17.5	2,300	6.9	6.8	30 [(c)]	200	10.5	12	-18.7
PW-2	5443.8	7.7	10.3	8/30/04	5454.1	18.0	2,000	6.0	9.3	54 [(d)]	500	12.2	12	-21.5
PW-3	5440.4	4.3	14.6	9/29/04	5455.0	18.9	1,100	3.3	13.6	95 [(d)]	1,300	17.0	12	-27.0
Pond 4	5436.1	0	---	---	---	0	0	---	---	---	---	---	---	

NOTES:
(a) Assumes 0.3 ft/100 ft friction headloss.
(b) Assumes discharge at 1 ft above ground level.
(c) Estimated from method of Driscoll, 2005, where Q/s = T/2000.
(d) Estimated from Mayo et.al., 2005.
(e) Assumes independent operation; disregards interference.
(f) Total estimated interference from other production wells flowing at flowrates shown; disregards well efficiencies.
(g) Piezometric surface head – pipe friction headloss – available artesian drawdown – total estimated interference -degassing.

wells are not large enough to accommodate pumps with these capacities. Furthermore, because the aquifer has not been pump-tested at flowrates that even approach these high values, there is no existing data that support these projections.

TABLE 1-3

BYU-PROJECTED MAXIMUM WELL PUMPING RATES

Well Number	Individual Pumping Flowrate[a] (gpm)	Simultaneous Pumping Flowrate[b] (gpm)
PW-1	900	800
PW-2	1,500	1,200
PW-3	2,150	1,700
Total	---	3,700

a) From Mayo et al., 2005, individual aquifer pumping test results.
b) Derived from unpublished data set used for aquifer analysis as documented by Mayo et al., 2005, simultaneous interference pumping test, flowrates approximate.

It may be possible to pump the individual wells at higher pumping rates than those recommended in the BYU evaluation. However, it is very important to note that there is uncertainty in determining the actual efficiency of each well; therefore there is some risk in drawing down the water level in any individual well below the upper confining tufa layer. This risk could be mitigated by installing an observation well immediately adjacent to each pumped well. The observation well could be two to four inches in diameter but would need to be screened within the same intervals as the associated pumping well. A pumping configuration that monitors water level in each pumped well and in the adjacent observation well, with a pressure transducer and programmable logic control (PLC) that regulates flowrate to prevent too much drawdown, would protect against overpumping. If each well pump is regulated by a variable frequency drive (VFD), the pump could operate continuously without frequent cycling while providing an optimal production flowrate.

1.2 Other Water Supply Issues

1.2.1 Water Rights. The DWR has a permitted groundwater nonconsumptive right for 10 cfs for the three new Midway Fish Hatchery wells.

Section 2

SECTION 2

DEVELOPMENT OF BIOCRITERIA FOR MODELING FISH REARING SYSTEMS AND PROGRAMS AT MIDWAY FISH HATCHERY

2.0 PURPOSE

The purpose of this section is to develop information to allow the modeling of the production programs at the Midway Fish Hatchery (MFH) and to present basic production information. Where ever possible the criteria will be compared to current values at other DWR facilities.

2.1 Feed Conversion

It is assumed, based upon review of hatchery practices and staff discussions, that the overall feed conversion is 1.1 to 1.0. (food to flesh). This is based on data from Midway Fish Hatchery but is typical of similar trout hatcheries elsewhere in the DWR system.

2.2 Length/Weight Relationships

It is often desirable to convert fish lengths to fish weights. The following relationships are used in most systems and are very similar to those used in Utah.

- For trout in Metric terms:

  L = Length in centimeters = 4.487 x $W^{(0.333)}$
  W = Weight in grams each = 0.01107 x $L^{(3.00)}$

- For trout in English terms

  L = Length in inches = 13.57 x $W^{(0.333)}$
  W = Weight in pounds = 0.0004 x $L^{(3.00)}$

- For salmon in English terms:

  L = Length in inches = 15.01 x $W^{(0.333)}$
  W = Weight in pounds = 0.0002959 x $L^{(3.00)}$

2.3 Incubation and Rearing Growth Rates

The timing and growth rate required for egg and fry development have been developed by programs. The basic information is as reported by the DWR staff for fish grown at Midway in the past and confirmed by comparison to other programs. These are presented as part of the production modeling.

2.3.1 Rainbow Trout (RT) and Rainbow Trout Triploid (RTTP). These eggs are typically received from July through December. The hatchery receives “eyed eggs” that have developed somewhat from their first eyeing (initial growth) conducted in another facility. Typically they require 40 days to "hatch" (begin feeding) at which time they are about 0.96 inch (2.4 cm) long. Based on a water temperature of 11°-12°C (51.8°-53.6°F) the development time for the developed "eyed eggs" stage to a size of 1.00 inch (swim up) is approximately 65 days.

From 1.00 inch in size they will continue to grow at a rate of between 0.012 to 0.022 inches/day, with maximum growth rates as high as 0.05 inches/day.

For Modeling Purposes we will use the following criteria:

- Developed "eyed eggs" stage to a size of 1.00 inch (swim up) 65 days
- From the 1.00 inch size to 3.00 inch (in hatch. bldg) 102 days
- From the 1.00 inch size 6-7 inches 230-275 days
- From 1.00 inch size to 10 inches 452 days

2.3.2 Cutthroat Trout – Bear Lake Strain (CTBLSB). These eggs are typically from wild stock collected in the field and brought to the hatchery. They can be spawned anytime from October to February. The eggs require 32 days to hatch and 25 days to swim up. The average development rate is about 0.015 inches per day at Midway water temperatures.

For Modeling Purposes we will use:

- "Eye egg" stage to a size of 1.00 inch 57 days
- From the 1.00 inch size to 6-7" (in hatch. bldg) 360-403 days

2.3.3 Kokanee Salmon (KS). These are typically from wild brood stock captured in the field in July. On spawning they are "green eggs". After fertilization they are "water hardened" eggs that will be transported into incubators at Midway. Typically they require about 63 days to "hatch". To reach the "all feeding" stage will typically require another 25 days at the Midway water temperature to swim up. At release they are about 3.0 inches long (0.012 inches/day).

For Modeling Purposes we will use:

- From the 1.00 inch size to 3" (in hatch. bldg) 170 days

2.4 Projected Planting Program for Midway Fish Hatchery

For the planning and programming purpose, the DWR staff has projected a planting program to produce approximately a million fish weighing approximately 198,500 lbs per year. As detailed on the Table 2-1 "Proposed New Midway Propagation Program", there are two programs. A one-year season program and a two-season program.

Table 2-1

Proposed New Midway Propagation Program

New Program Stock	Stocking Length (in)	Stocking Lb	Stocking Fish/lb	# Fish	Piper's DI	Piper's FI	Length-Weight c
CTBLSB	7	43,494	8.3	361,000	0.35	1.3	0.0003327
CTBLSB	6	15,152	13.2	200,000	0.35	1.3	0.0003327
KS	3	3,240	92.6	300,000	0.35	1.26	0.0003984
RT	3	5,782	88.2	510,000	0.35	1.1	0.0004109
RTTP	6	30,455	11	335,000	0.35	1.1	0.00041
RTTP	7	32,319	6.9	223,000	0.35	1.1	0.00041
RT	10	68,000	2.5	170,000	0.35	1.1	0.0004109
TOTAL		**198,442.00**		**2,099,000**			

Stock Cont'd	Growth (in/day)	Egg Date	Days to Hatch	Hatch Date	Days to SU	SU date	Stocking Date	Rearing Days	Initial Hatch Length (in)	Survival Egg to SU	Survival SU-Stocking
CTBLSB	0.015	2/9/2006	32	3/13/2006	25	4/7/2006	5/15/2007	403	0.96	50%	60%
CTBLSB	0.015	10/2/2006	32	11/3/2006	25	11/28/2006	10/30/2007	336	0.96	50%	65%
KS	0.012	7/31/2006	63	10/2/2006	25	10/27/2006	4/15/2007	170	0.96	78%	60%
RT	0.02	12/14/2006	40	1/23/2007	25	2/17/2007	5/30/2007	102	0.96	90%	70%
RTTP	0.022	7/24/2006	40	9/2/2006	25	9/27/2006	5/15/2007	229	0.96	90%	70%
RTTP	0.022	11/24/2006	40	1/3/2007	25	1/28/2007	10/30/2007	275	0.96	90%	70%
RT	0.02	12/29/2005	40	2/7/2006	25	3/4/2006	5/30/2007	452	0.96	90%	70%

2.5 Biological and Water Quality Criteria

2.5.1 Inflow Dissolved Oxygen (DO) Criteria. Water at this site will be derived from three wells and is expected to typically have a well DO concentration of 5.0 to 6.0 mg/l and has a pH of 7.0±. After well pumping it will be treated through a degassing/aeration system which typically raise the DO to 96+% saturation.

At this site (5,500' elevation and 11°C water temperature) 100% saturation will be approximately 9.04 mg/l. <u>This assumes that no oxygen is being injected</u>. For reference, when oxygen is being injected it commonly can raise the oxygen content in the water to above 12 mg/l before it is distributed to the rearing facilities.

2.5.2 Effluent Dissolved Oxygen (DO) Criteria. In a simple flow-through system, available oxygen is the incoming influent oxygen less the minimum acceptable effluent (DO in water leaving the rearing unit) oxygen. The minimum acceptable effluent oxygen levels for salmonids are sometimes defined as a specific value such as 6.0 mg/l under all conditions (effluent water DO). Increasingly the minimums are proposed at some value that relates to a constant partial pressure of oxygen, which we suggest should be 90 mm Hg. Others have suggested variable DO concentration values in the 5.0 to 7.5 mg/l range, based on the size and type of fish, with larger fish and less sensitive species having lower possible effluent DO criteria.

For this study we will avoid refining dual effluent criteria and adopt a single conservative but realistic value. We propose that the average daily effluent oxygen levels be set at 90 mm Hg. At this location this is a DO value of 6.0 mg/l or no lower than 65% saturation (at 5,500 feet above sea level).

2.5.3 Carbon Dioxide (CO_2) Criteria. It is not unusual to see maximum CO_2 criteria put forth at values of 10-15 mg/l. We suggest a criterion of 10.0 mg/l. This does not appear to be a problem since concentrations measured in the field were below this threshold

2.5.4 pH Criteria. We propose a pH range of 6.5 to 8.0 as a water quality criteria.

2.5.5 Ammonia (un-ionized as N) Criteria. We propose a maximum concentration criteria of 0.010 to 0.012 mg/l as unionized (NH_3) ammonia. At the maximum flow and calculated feeding rate (based upon our modeling) total maximum unionized ammonia could reach as high as 0.018 mg/l in raceway rearing for a one-week period.

2.5.6 Oxygen Consumption (Oc). Willowby (Piper, 1982) proposed an oxygen consumption (Oc) value equal to 22% x F (F = feed amount) for a dry diet that was 90% solids. Wood proposed 25% for a moist diet that was 72% solids and BioOregon (feed manufacturer) suggested that for a diet formulation similar to theirs (approximately 80% solids), some intermediate Oc value should be appropriate.

These values are generally considered average daily and peak values. After discussions with the staff relative to their recent measurements and internal discussions between the consultant team, we propose the following values for modeling:

- Average consumption rate .... Oc=24% x F
- Peak consumption rate .... Oc=30% x F

Where F is the amount of food fed to the fish in a day and Oc is the Oxygen Consumption. The amount of food fed may also be calculated by the fish weight gained in a day times the feed conversion factor.

2.5.7 Density Indexes (DI). The term density index (DI) is often used by fish culturists to provide a basis for comparing fish densities (mass per volume unit) in rearing for fish of differing sizes. The accepted general form for calculating DI in English units (more common in fish husbandry and used exclusively herein) is:

DI = M/((TL)(V)) = D/TL

D	=	Density of fish (lb/ft^3 of rearing space)
M	=	Mass of fish in rearing unit (lb)
V	=	Volume of rearing unit (ft^3)
DI	=	Density index (lb/ft^3(inch)
TL	=	Total length of fish (inches)

Piper suggested a DI = 0.5 for federal hatcheries and this is a commonly used value in many state systems. Recent research has strongly pointed to lesser values (down to 0.15) for achieving higher quality salmon at release, but the majority of states continue to target the 0.5 value.

At Midway the DI in the raceways, established by DWR, was 0.35 in any individual unit.

The recent trend is to use lower values with the expectation of growing a better, healthier fish. However, this assumption must be demonstrated to the satisfaction of the individual grower. Where a value is required in our modeling calculation we will use a DI value equal to 0.35 as an initial maximum goal for all species and groups.

2.5.8 Survival. Hatchery managers expect a survival rate of at least 60% - 90% through rearing. In modeling we will assume the following survival values:

	CTBLSB	KS	RT
• Incubation to swim up	50%	78%	90%
• Swim up to stocking	60-65%	60%	70%

2.5.9 Flow Indexes (FI). The material presented above provides the basis for calculating the flows required to meet the criteria for water quality (oxygen) established in this section. We can put this in the form of a flow index (FI) that is generally familiar to fish culturists.

FI x Length in inches = Required flow in lbs/gpm (lbs of fish per gallon per minute of flow)

Flow indexes are most commonly used in hatcheries that do not use oxygen supplementation to determine the amount of flow required. However, it is possible to calculate flow indexes for situations when the known oxygen supplementation is used. For the Midway project the DWR staff and consultant team selected the following flow index goals:

Group	**FI**
CTBLS	1.30
KS	1.26
RT	1.10

Section 3

SECTION 3

MIDWAY FISH HATCHERY PROGRAM MODELING

3.0 INTRODUCTION

In order to estimate the basic design criteria for the new Midway Fish Hatchery, a model was developed that evaluated the following parameters:

1) Species and Schedule
2) Water Requirements
3) Rearing Space Requirements
4) Rearing Unit Requirements
5) Feed Requirements
6) Phosphorus Discharge

Since the Midway Fish Hatchery has been out of production (with the exception of the recent reduced indoor cutthroat program) for over 4 years, new rearing objectives for species, timing/schedule and number/pounds of product for future planting were developed by DWR for input to the MWH model. Table 3-1 (DWR 2004) provides the historic (2000) and proposed future program goals for the new hatchery.

Based upon these objectives, a model was developed that will provide annual production cycles for each of the programs that DWR identified. We have classified the program elements using letters A – G which relate to the species/group and size of fish at release. The model uses a weekly time step to analyze growth, feed, water, and space requirements, and the waste load total phosphorus produced. Waste discharge phosphorus will be a critical operational element at Midway Fish Hatchery due to the anticipated limit of 400 Kg/year net total phosphorus that is expected to be imposed on the new hatchery. These program elements include:

Program Identification	Identify	Abbreviation	Size
A	Bear Lake Strain Cutthroat Trout	(CTBLSB)	7 inches
B	Bear Lake Strain Cutthroat Trout	(CTBLSB)	6 inches
C	Kokanee Salmon	(KS)	3 inches
D	Rainbow Trout	(RT)	3 inches
E	Rainbow Trout Triploid	(RTTP)	6 inches
F	Rainbow Trout Triploid	(RTTP)	7 inches
G	Rainbow Trout	(RT)	10 inches

Table 3-1

Proposed New Midway Propagation Program

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RT	0.02	12/29/2005	40	2/7/2006	25	3/4/2006	5/30/2007	452	0.96	90%	70%

With the exception of Programs A and G, the production for each program can be accomplished within one 12-month (annual) cycle. Cycle carryover assumptions for Program A and G in this model are conservative in terms of space and water requirements and in actuality the physical requirements can be reduced by allowing a less restrictive density (higher density index) and lower flows per unit of fish (reduced flow index) than the limits the model has employed and by the use of oxygenated serial reuse. It is also possible to reduce the water demand by moving fish from early rearing to raceway rearing earlier than the 3-inch length limit assumed in the model. The model can be used as a “what if” tool to look at various rearing parameters and production options. It should not be considered as an absolute predictor of the production limits or rearing success. The assumption used, many provided by DWR to MWH over the last 10 years, are only what they purport to be – assumptions. Parameters such as survival (mortality), food conversion and feeding rates and timing for release regularly differ, in actual hatchery operation, from the numbers presented herein. The model provides a conservative basis to establish preliminary design criteria, schematic design layout and budget level construction cost estimating that will be further refined as the project design progresses.

Table 3-2 provides the basic program information used in developing the model along with assumptions that were developed for evaluating individual culture programs. For example, an individual raceway unit volume of 2,625 cf (93’ x 3.5’ x 8’ actual rearing space) has been assumed for determining the theoretical number of raceways needed to meet the total calculated rearing volume required. This unit size will be altered in design but the assumption provides an initial indication of how large the system will need to be in order to support the target program objectives.

The water, space, and total phosphorus (TP) discharge was modeled for calendar years 2002 to 2012. Calendar year 2009 was used to generate summary data for the overall hatchery program. [The choice of 2009 is arbitrary as long as the requirements of the 2-year programs are included].

Appendix A provides an electronic copy of the full model with, where appropriate, multiple years of cycle time to assess the effect of program overlap on water demand and required space. One cycle covers the total rearing schedule from egg received to final program size objective for each species. Program A (Bear Lake Strain Cutthroat) and Program G (10” Rainbow Trout) require a growth period longer than a one-year (12 month) cycle. Therefore, the maturing stock from one-year will overlap the new stock for the next cycle. This requires that water flow and rearing space requirements be increased to include the overlap cycle. The summary Tables 3-3 to 3-7 present the model in terms of water flow, rearing space, and food requirements. Survival through incubation, swim up (SU) and rearing were assumed based upon earlier discussions with DWR (see Table 3-2). Flow and rearing space requirements were assumed using the conventional planning Flow Index and Density Index used for that particular species as provided by the State of Utah or taken from Piper (1982). As discussed earlier, all of our assumptions are predicated on information provided by DWR for Midway Fish Hatchery, conventional fish husbandry criteria, or based upon previous projects completed for DWR. Any of this information can be modified to better conform to actual experience for the Midway Fish Hatchery Program.

Table 3-2

New Program Summary

Stock	Stocking Length (in)	Stocking Lb	Stocking Fish/lb	# Fish	Model Group	Piper's DI	Piper's FI	Length-Weight "c"	Growth (in/day)	Egg Date	Days to Hatch	Hatch Date	Days to SU	SU date	Stocking Date	Rearing Days	Initial Hatch Length (in)	Survival Egg to SU	Survival SU-Stocking	Stock	FCR lb feed/lb fish	P Production (TP lb/lb feed)	% Soluble (of total excr)	% Fecal (of total excr)	% Decay (from Fecal)	% Solids Removal	Model Group
CTBLSB	7.00	43,494	8.3	361,000	A (even/odd)	0.35	1.30	0.0003327	0.015	2/8/2002	32	3/12/2002	25	4/6/2002	5/14/2003	403	0.96	50%	60%	CTBLSB	1.1	0.78%	26%	74%	40%	60%	A (even/odd)
CTBLSB	6.00	15,152	13.2	200,000	B	0.35	1.30	0.0003327	0.015	10/1/2002	32	11/2/2002	25	11/27/2002	10/29/2003	336	0.96	50%	65%	CTBLSB	1.1	0.78%	26%	74%	40%	60%	B
KS	3.00	3,240	92.6	300,000	C	0.35	1.26	0.0003984	0.012	7/30/2002	63	10/1/2002	25	10/26/2002	4/14/2003	170	0.96	78%	60%	KS	1.1	0.78%	26%	74%	40%	60%	C
RT	3.00	5,782	88.2	510,000	D	0.35	1.10	0.0004109	0.020	12/13/2002	40	1/22/2003	25	2/16/2003	5/29/2003	102	0.96	90%	70%	RT	1.2	0.78%	26%	74%	40%	60%	D
RTTP	6.00	30,455	11	335,000	E	0.35	1.10	0.0004100	0.022	7/23/2002	40	9/1/2002	25	9/26/2002	5/14/2003	229	0.96	90%	70%	RTTP	1.1	0.78%	26%	74%	40%	60%	E
RTTP	7.00	32,319	6.9	223,000	F	0.35	1.10	0.0004100	0.022	11/23/2002	40	1/2/2003	25	1/27/2003	10/29/2003	275	0.96	90%	70%	RTTP	1.1	0.78%	26%	74%	40%	60%	F
RT	10.00	68,000	2.5	170,000	G (even/odd)	0.35	1.10	0.0004109	0.020	12/28/2001	40	2/6/2002	25	3/3/2002	5/29/2003	452	0.96	90%	70%	RT	1.2	0.78%	26%	74%	40%	60%	G (even/odd)
TOTAL		**198,442.0**		**2,099,000**																							

Stock	Total P in feed (%)	P excreted (% of total in feed)
CTBLSB	1.00%	78%
CTBLSB	1.00%	78%
KS	1.00%	78%
RT	1.00%	78%
RTTP	1.00%	78%
RTTP	1.00%	78%
RT	1.00%	78%

Note:
22% retained by fish
20% soluble
58% fecal

Of the excreted P, soluble is 25.6% and fecal is 74.4%

P Discharged
1,511 lb P/year
686 kg/year

Assumptions:
(1) All SU mortality occurs on the last day.
(2) Fry are held indoors (if possible) to 3" (on at least 2" for large lots)
(3) DI for early rearing can be increased to 0.70 - 1.00 for fish up to 2"
(4) Rearing volume for early rearing and rearing is computed for the end of the process. (fish are not split)
(5) Indoor rearing uses first-pass water only.
(6) Indoor early rearing units = 60 cf
(7) Rearing units = 2625 cf
(8) Start of early rearing and incubation are computed from stocking date
(9) 7" CTBLSB and 10" RT are multi-year program and have separate even and odd year programs based on stocking dates

Table 3-3
First Pass Water Requirements of Incubation and Early Rearing

Date	Flow in GPM For Each Program									
0	A(even)	A(odd)	B	C	D	E	F	G(even)	G(odd)	TOTAL
1/4/2009	0	0	378	465	279	0	0	0	0	1,121
1/11/2009	0	0	417	497	329	0	0	0	0	1,243
1/18/2009	0	0	458	528	409	0	0	0	0	1,395
1/25/2009	0	0	0	560	495	0	122	0	0	1,177
2/1/2009	0	0	0	592	587	0	122	0	0	1,300
2/8/2009	0	0	0	623	684	0	122	0	93	1,521
2/15/2009	0	0	0	654	784	0	147	0	93	1,678
2/22/2009	0	0	0	684	888	0	189	0	93	1,855
3/1/2009	0	0	0	713	995	0	236	0	110	2,055
3/8/2009	0	0	0	742	1,104	0	288	0	139	2,273
3/15/2009	0	284	0	770	1,214	0	344	0	171	2,783
3/22/2009	0	284	0	797	1,325	0	405	0	207	3,017
3/29/2009	0	284	0	823	1,436	0	0	0	245	2,787
4/5/2009	0	284	0	847	1,545	0	0	0	287	2,963
4/12/2009	0	284	0	0	1,654	0	0	0	332	2,269
4/19/2009	0	284	0	0	1,760	0	0	0	380	2,423
4/26/2009	0	175	0	0	0	0	0	0	0	175
5/3/2009	0	209	0	0	0	0	0	0	0	209
5/10/2009	0	247	0	0	0	0	0	0	0	247
5/17/2009	0	287	0	0	0	0	0	0	0	287
5/24/2009	0	330	0	0	0	0	0	0	0	330
5/31/2009	0	376	0	0	0	0	0	0	0	376
6/7/2009	0	424	0	0	0	0	0	0	0	424
6/14/2009	0	474	0	0	0	0	0	0	0	474
6/21/2009	0	527	0	0	0	0	0	0	0	527
6/28/2009	0	582	0	0	0	0	0	0	0	582
7/5/2009	0	0	0	0	0	0	0	0	0	0
7/12/2009	0	0	0	0	0	0	0	0	0	0
7/19/2009	0	0	0	0	0	0	0	0	0	0
7/26/2009	0	0	0	0	0	0	0	0	0	0
8/2/2009	0	0	0	0	0	0	0	0	0	0
8/9/2009	0	0	0	0	0	0	0	0	0	0
8/16/2009	0	0	0	0	0	0	0	0	0	0
8/23/2009	0	0	0	0	0	0	0	0	0	0
8/30/2009	0	0	0	0	0	183	0	0	0	183
9/6/2009	0	0	0	0	0	183	0	0	0	183
9/13/2009	0	0	0	0	0	183	0	0	0	183
9/20/2009	0	0	0	0	0	221	0	0	0	221
9/27/2009	0	0	0	0	0	284	0	0	0	284
10/4/2009	0	0	0	187	0	354	0	0	0	541
10/11/2009	0	0	0	187	0	430	0	0	0	617
10/18/2009	0	0	0	187	0	514	0	0	0	700
10/25/2009	0	0	236	172	0	603	0	0	0	1,011
11/1/2009	0	0	236	198	0	0	0	0	0	434
11/8/2009	0	0	236	224	0	0	0	0	0	460
11/15/2009	0	0	145	252	0	0	0	0	0	397
11/22/2009	0	0	173	280	0	0	0	0	0	453
11/29/2009	0	0	203	310	0	0	0	0	0	512
12/6/2009	0	0	234	340	0	0	0	0	0	574
12/13/2009	0	0	268	370	0	0	0	0	0	638
12/20/2009	0	0	303	402	0	0	0	0	0	704
12/27/2009	0	0	339	433	0	0	0	0	0	773
Maximum	0	582	458	847	1,760	603	405	0	380	3,017

Table 3-4
Reuse and First Pass Water for Raceway Rearing

Dates	Reuse and First Pass Flow in GPM									
Date	A(even)	A(odd)	B	C	D	E	F	G(even)	G(odd)	TOTAL
1/4/2009	2,968	0	0	0	0	1,795	0	3,789	0	8,552
1/11/2009	3,060	0	0	0	0	1,938	0	3,913	0	8,911
1/18/2009	3,152	0	0	0	0	2,085	0	4,038	0	9,275
1/25/2009	3,244	0	499	0	0	2,235	0	4,164	0	10,142
2/1/2009	3,335	0	542	0	0	2,388	0	4,291	0	10,557
2/8/2009	3,427	0	586	0	0	2,544	0	4,419	0	10,976
2/15/2009	3,518	0	630	0	0	2,703	0	4,548	0	11,399
2/22/2009	3,609	0	675	0	0	2,863	0	4,677	0	11,825
3/1/2009	3,700	0	721	0	0	3,026	0	4,807	0	12,254
3/8/2009	3,790	0	767	0	0	3,190	0	4,938	0	12,685
3/15/2009	3,879	0	814	0	0	3,356	0	5,070	0	13,119
3/22/2009	3,968	0	861	0	0	3,524	0	5,202	0	13,554
3/29/2009	4,056	0	908	0	0	3,692	470	5,334	0	14,460
4/5/2009	4,143	0	955	0	0	3,861	539	5,468	0	14,966
4/12/2009	4,230	0	1,001	0	0	4,031	612	5,601	0	15,476
4/19/2009	4,315	0	1,048	0	0	4,201	690	5,735	0	15,989
4/26/2009	4,400	0	1,095	0	0	4,371	771	5,869	430	16,936
5/3/2009	4,484	0	1,141	0	0	4,541	855	6,004	484	17,509
5/10/2009	4,566	0	1,186	0	0	0	944	5,642	540	12,879
5/17/2009	0	0	1,231	0	0	0	1,035	5,253	599	8,119
5/24/2009	0	0	1,275	0	0	0	1,130	4,834	661	7,901
5/31/2009	0	0	1,319	0	0	0	1,228	4,385	726	7,659
6/7/2009	0	0	1,361	0	0	0	1,329	3,907	793	7,390
6/14/2009	0	0	1,403	0	0	0	1,433	3,397	863	7,096
6/21/2009	0	0	1,443	0	0	0	1,540	2,855	936	6,773
6/28/2009	0	0	1,482	0	0	0	1,649	2,281	1,010	6,422
7/5/2009	0	640	1,520	0	0	0	1,761	1,674	1,088	6,682
7/12/2009	0	700	1,556	0	0	0	1,875	1,033	1,168	6,331
7/19/2009	0	762	1,590	0	0	0	1,991	358	1,250	5,950
7/26/2009	0	826	1,623	0	0	0	2,109	0	1,334	5,892
8/2/2009	0	891	1,654	0	0	0	2,230	0	1,421	6,196
8/9/2009	0	959	1,684	0	0	0	2,352	0	1,509	6,504
8/16/2009	0	1,029	1,711	0	0	0	2,476	0	1,600	6,815
8/23/2009	0	1,100	1,736	0	0	0	2,601	0	1,693	7,130
8/30/2009	0	1,173	1,759	0	0	0	2,728	0	1,788	7,448
9/6/2009	0	1,248	1,779	0	0	0	2,856	0	1,885	7,768
9/13/2009	0	1,324	1,797	0	0	0	2,985	0	1,984	8,090
9/20/2009	0	1,402	1,813	0	0	0	3,115	0	2,085	8,414
9/27/2009	0	1,481	1,825	0	0	0	3,246	0	2,188	8,740
10/4/2009	0	1,561	1,835	0	0	0	3,378	0	2,292	9,066
10/11/2009	0	1,643	1,843	0	0	0	3,510	0	2,398	9,394
10/18/2009	0	1,726	0	0	0	0	3,643	0	2,506	7,875
10/25/2009	0	1,810	0	0	0	0	3,776	0	2,615	8,201
11/1/2009	0	1,895	0	0	0	699	3,910	0	2,726	9,230
11/8/2009	0	1,980	0	0	0	800	4,043	0	2,839	9,663
11/15/2009	0	2,067	0	0	0	907	0	0	2,953	5,928
11/22/2009	0	2,155	0	0	0	1,020	0	0	3,069	6,243
11/29/2009	0	2,243	0	0	0	1,138	0	0	3,185	6,566
12/6/2009	0	2,332	0	0	0	1,260	0	0	3,304	6,896
12/13/2009	0	2,422	0	0	0	1,387	0	0	3,423	7,232
12/20/2009	0	2,512	0	0	0	1,519	0	0	3,544	7,575
12/27/2009	0	2,603	0	0	0	1,655	0	0	3,666	7,923
Maximum	4,566	2,603	1,843	0	0	4,541	4,043	6,004	3,666	17,509

Table 3-5
Early Rearing Space Requirements in 60 Cubic Foot Units

Date	A(even)	A(odd)	B	C	D	E	F	G(even)	G(odd)	Total Units	Total CF
01/04/09	7	0	0	0	0	6	0	8	0	21	1260
01/11/09	7	0	0	0	0	6	0	8	0	21	1260
01/18/09	7	0	3	0	0	6	0	8	0	24	1440
01/25/09	7	0	3	0	0	6	0	8	0	24	1440
02/01/09	7	0	3	0	0	6	0	8	0	24	1440
02/08/09	7	0	3	0	0	6	0	8	0	24	1440
02/15/09	7	0	3	0	0	6	0	8	0	24	1440
02/22/09	7	0	3	0	0	6	0	8	0	24	1440
03/01/09	7	0	3	0	0	6	0	8	0	24	1440
03/08/09	7	0	3	0	0	6	0	8	0	24	1440
03/15/09	7	0	3	0	0	6	0	8	0	24	1440
03/22/09	7	0	3	0	0	6	5	8	0	29	1740
03/29/09	7	0	3	0	0	6	5	8	0	29	1740
04/05/09	7	0	3	0	0	6	5	8	8	37	2220
04/12/09	7	0	3	0	0	6	5	8	8	37	2220
04/19/09	7	0	3	0	0	6	5	8	8	37	2220
04/26/09	7	0	3	0	0	6	5	8	8	37	2220
05/03/09	7	0	3	0	0	0	5	8	8	31	1860
05/10/09	0	0	3	0	0	0	5	7	8	23	1380
05/17/09	0	0	3	0	0	0	5	7	8	23	1380
05/24/09	0	0	3	0	0	0	5	6	8	22	1320
05/31/09	0	0	3	0	0	0	5	5	8	21	1260
06/07/09	0	0	3	0	0	0	5	5	8	21	1260
06/14/09	0	0	3	0	0	0	5	4	8	20	1200
06/21/09	0	0	3	0	0	0	5	4	8	20	1200
06/28/09	0	7	3	0	0	0	5	3	8	26	1560
07/05/09	0	7	3	0	0	0	5	2	8	25	1500
07/12/09	0	7	3	0	0	0	5	1	8	24	1440
07/19/09	0	7	3	0	0	0	5	0	8	23	1380
07/26/09	0	7	3	0	0	0	5	0	8	23	1380
08/02/09	0	7	3	0	0	0	5	0	8	23	1380
08/09/09	0	7	3	0	0	0	5	0	8	23	1380
08/16/09	0	7	3	0	0	0	5	0	8	23	1380
08/23/09	0	7	3	0	0	0	5	0	8	23	1380
08/30/09	0	7	3	0	0	0	5	0	8	23	1380
09/06/09	0	7	3	0	0	0	5	0	8	23	1380
09/13/09	0	7	3	0	0	0	5	0	8	23	1380
09/20/09	0	7	3	0	0	0	5	0	8	23	1380
09/27/09	0	7	3	0	0	0	5	0	8	23	1380
10/04/09	0	7	3	0	0	0	5	0	8	23	1380
10/11/09	0	7	0	0	0	0	5	0	8	20	1200
10/18/09	0	7	0	0	0	0	5	0	8	20	1200
10/25/09	0	7	0	0	0	0	5	0	8	20	1200
11/01/09	0	7	0	0	0	0	5	0	8	20	1200
11/08/09	0	7	0	0	0	0	0	0	8	15	900
11/15/09	0	7	0	0	0	0	0	0	8	15	900
11/22/09	0	7	0	0	0	6	0	0	8	21	1260
11/29/09	0	7	0	0	0	6	0	0	8	21	1260
12/06/09	0	7	0	0	0	6	0	0	8	21	1260
12/13/09	0	7	0	0	0	6	0	0	8	21	1260
12/20/09	0	7	0	0	0	6	0	0	8	21	1260
12/27/09	0	7	0	0	0	6	0	0	8	21	1260
Maximum	7	7	3	0	0	6	5	8	8	37	2220

Table 3-6
Raceway Space Requirements in 2625 Cubic Foot Rearing Units

Date	A(even)	A(odd)	B	C	D	E	F	G(even)	G(odd)	TOTAL Units	Total CF
01/04/09	7	0	0	0	0	6	0	8	0	21	55125
01/11/09	7	0	0	0	0	6	0	8	0	21	55125
01/18/09	7	0	3	0	0	6	0	8	0	24	63000
01/25/09	7	0	3	0	0	6	0	8	0	24	63000
02/01/09	7	0	3	0	0	6	0	8	0	24	63000
02/08/09	7	0	3	0	0	6	0	8	0	24	63000
02/15/09	7	0	3	0	0	6	0	8	0	24	63000
02/22/09	7	0	3	0	0	6	0	8	0	24	63000
03/01/09	7	0	3	0	0	6	0	8	0	24	63000
03/08/09	7	0	3	0	0	6	0	8	0	24	63000
03/15/09	7	0	3	0	0	6	0	8	0	24	63000
03/22/09	7	0	3	0	0	6	5	8	0	29	76125
03/29/09	7	0	3	0	0	6	5	8	0	29	76125
04/05/09	7	0	3	0	0	6	5	8	8	37	97125
04/12/09	7	0	3	0	0	6	5	8	8	37	97125
04/19/09	7	0	3	0	0	6	5	8	8	37	97125
04/26/09	7	0	3	0	0	6	5	8	8	37	97125
05/03/09	7	0	3	0	0	0	5	8	8	31	81375
05/10/09	0	0	3	0	0	0	5	7	8	23	60375
05/17/09	0	0	3	0	0	0	5	7	8	23	60375
05/24/09	0	0	3	0	0	0	5	6	8	22	57750
05/31/09	0	0	3	0	0	0	5	5	8	21	55125
06/07/09	0	0	3	0	0	0	5	5	8	21	55125
06/14/09	0	0	3	0	0	0	5	4	8	20	52500
06/21/09	0	0	3	0	0	0	5	4	8	20	52500
06/28/09	0	7	3	0	0	0	5	3	8	26	68250
07/05/09	0	7	3	0	0	0	5	2	8	25	65625
07/12/09	0	7	3	0	0	0	5	1	8	24	63000
07/19/09	0	7	3	0	0	0	5	0	8	23	60375
07/26/09	0	7	3	0	0	0	5	0	8	23	60375
08/02/09	0	7	3	0	0	0	5	0	8	23	60375
08/09/09	0	7	3	0	0	0	5	0	8	23	60375
08/16/09	0	7	3	0	0	0	5	0	8	23	60375
08/23/09	0	7	3	0	0	0	5	0	8	23	60375
08/30/09	0	7	3	0	0	0	5	0	8	23	60375
09/06/09	0	7	3	0	0	0	5	0	8	23	60375
09/13/09	0	7	3	0	0	0	5	0	8	23	60375
09/20/09	0	7	3	0	0	0	5	0	8	23	60375
09/27/09	0	7	3	0	0	0	5	0	8	23	60375
10/04/09	0	7	3	0	0	0	5	0	8	23	60375
10/11/09	0	7	0	0	0	0	5	0	8	20	52500
10/18/09	0	7	0	0	0	0	5	0	8	20	52500
10/25/09	0	7	0	0	0	0	5	0	8	20	52500
11/01/09	0	7	0	0	0	0	5	0	8	20	52500
11/08/09	0	7	0	0	0	0	0	0	8	15	39375
11/15/09	0	7	0	0	0	0	0	0	8	15	39375
11/22/09	0	7	0	0	0	6	0	0	8	21	55125
11/29/09	0	7	0	0	0	6	0	0	8	21	55125
12/06/09	0	7	0	0	0	6	0	0	8	21	55125
12/13/09	0	7	0	0	0	6	0	0	8	21	55125
12/20/09	0	7	0	0	0	6	0	0	8	21	55125
12/27/09	0	7	0	0	0	6	0	0	8	21	55125
Maximum	7	7	3	0	0	6	5	8	8	37	97125

Table 3-7
Feed Inputs in lb/week for Each Program

Date	A(even)	A(odd)	B	C	D	E	F	G(even)	G(odd)	TOTAL
1/4/2009	1,310	0	160	155	0	959	0	2,060	0	4,645
1/11/2009	1,351	0	178	166	0	1,037	0	2,128	0	4,861
1/18/2009	1,392	0	196	177	202	1,118	0	2,197	0	5,283
1/25/2009	1,433	0	214	188	248	1,201	0	2,267	0	5,550
2/1/2009	1,474	0	233	199	296	1,285	0	2,337	0	5,824
2/8/2009	1,515	0	252	210	348	1,371	0	2,407	0	6,103
2/15/2009	1,556	0	272	220	402	1,458	0	2,478	0	6,386
2/22/2009	1,597	0	292	231	458	1,546	94	2,549	0	6,767
3/1/2009	1,637	0	312	241	515	1,636	118	2,621	0	7,082
3/8/2009	1,678	0	333	251	574	1,727	146	2,693	69	7,470
3/15/2009	1,718	0	353	261	634	1,819	176	2,765	86	7,811
3/22/2009	1,758	0	374	270	694	1,911	208	2,838	104	8,158
3/29/2009	1,797	0	395	279	754	2,004	243	2,911	125	8,509
4/5/2009	1,837	0	416	288	814	2,098	281	2,985	147	8,865
4/12/2009	1,875	0	437	0	874	2,192	320	3,058	171	8,927
4/19/2009	1,914	0	458	0	932	2,286	362	3,132	197	9,280
4/26/2009	1,952	0	478	0	0	2,380	406	3,206	224	8,647
5/3/2009	1,989	86	499	0	0	2,475	452	3,280	253	9,034
5/10/2009	2,026	102	519	0	0	0	501	3,084	283	6,515
5/17/2009	0	120	539	0	0	0	551	2,871	315	4,396
5/24/2009	0	138	559	0	0	0	602	2,643	349	4,291
5/31/2009	0	158	579	0	0	0	656	2,398	384	4,175
6/7/2009	0	179	598	0	0	0	712	2,137	420	4,045
6/14/2009	0	201	616	0	0	0	769	1,858	458	3,902
6/21/2009	0	225	634	0	0	0	827	1,562	497	3,745
6/28/2009	0	249	652	0	0	0	887	1,248	538	3,574
7/5/2009	0	274	669	0	0	0	949	916	580	3,388
7/12/2009	0	301	685	0	0	0	1,011	565	623	3,186
7/19/2009	0	328	701	0	0	0	1,075	196	668	2,968
7/26/2009	0	356	715	0	0	0	1,141	0	714	2,926
8/2/2009	0	385	730	0	0	0	1,207	0	761	3,083
8/9/2009	0	415	743	0	0	0	1,274	0	810	3,242
8/16/2009	0	446	755	0	0	0	1,343	0	860	3,403
8/23/2009	0	478	766	0	0	0	1,412	0	910	3,566
8/30/2009	0	510	777	0	0	0	1,482	0	962	3,731
9/6/2009	0	543	786	0	0	0	1,553	0	1,015	3,897
9/13/2009	0	577	794	0	0	0	1,624	0	1,070	4,065
9/20/2009	0	611	802	0	0	0	1,696	0	1,125	4,234
9/27/2009	0	647	807	0	0	140	1,769	0	1,181	4,544
10/4/2009	0	682	812	0	0	177	1,842	0	1,238	4,751
10/11/2009	0	719	816	0	0	218	1,915	0	1,296	4,964
10/18/2009	0	755	0	0	0	262	1,989	0	1,356	4,362
10/25/2009	0	793	0	0	0	310	2,063	0	1,416	4,581
11/1/2009	0	831	0	64	0	362	2,137	0	1,477	4,870
11/8/2009	0	869	0	73	0	417	2,211	0	1,538	5,108
11/15/2009	0	908	0	82	0	475	0	0	1,601	3,066
11/22/2009	0	947	71	92	0	536	0	0	1,664	3,310
11/29/2009	0	986	84	102	0	600	0	0	1,729	3,501
12/6/2009	0	1,026	98	112	0	667	0	0	1,794	3,696
12/13/2009	0	1,066	112	123	0	736	0	0	1,859	3,896
12/20/2009	0	1,106	128	134	0	808	0	0	1,926	4,101
12/27/2009	0	1,147	144	144	0	882	0	0	1,993	4,309
Maximum (lb	2,026	1,147	816	288	932	2,475	2,211	3,280	1,993	9,280
Total (lb)	31,811	19,162	22,541	4,063	7,746	37,093	38,002	67,392	36,783	264,593

3.1 Water Requirement

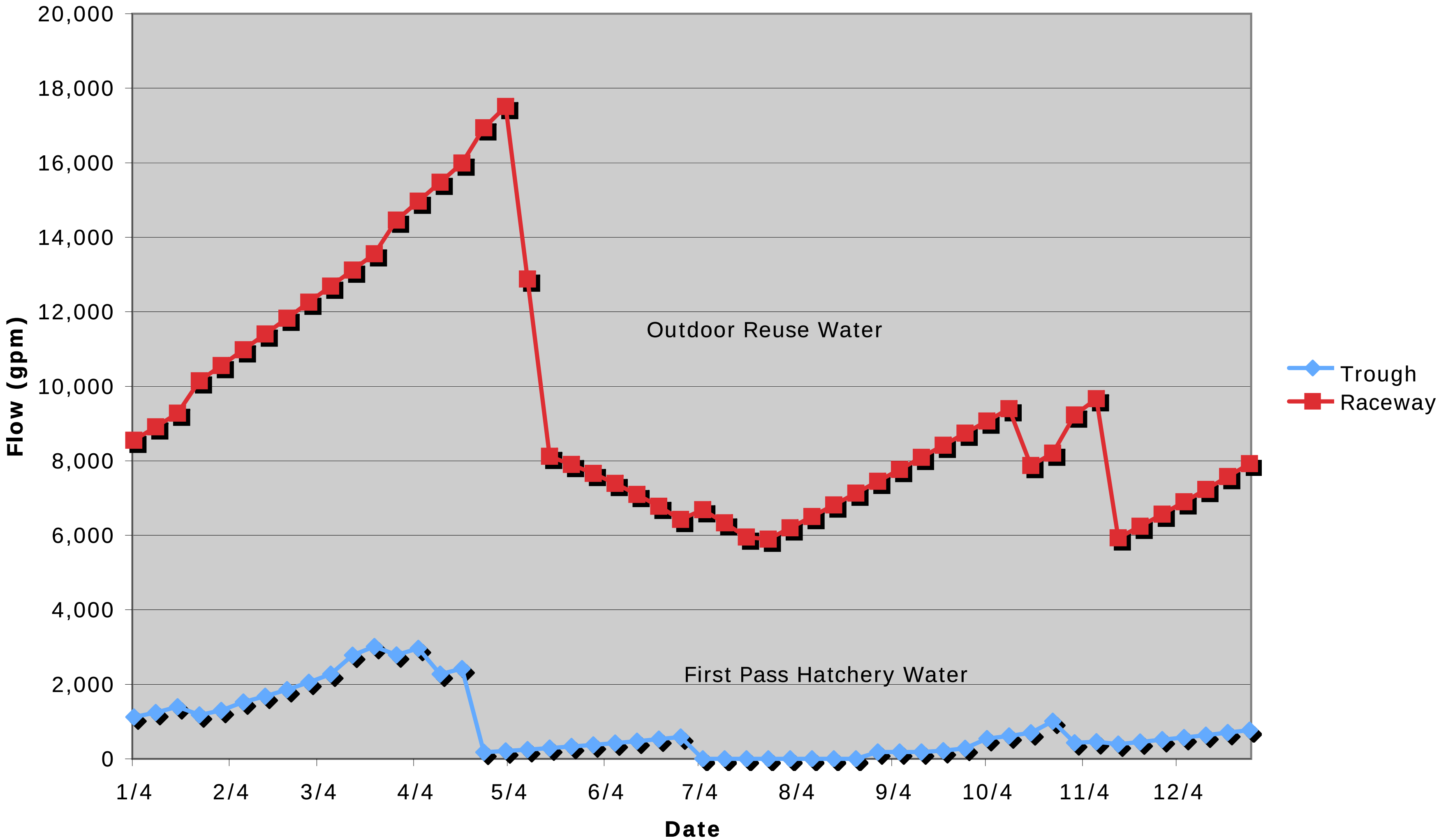
Table 3-3 provides a summary of the first pass (no reuse) water requirements by program (species and size) for incubation and early rearing. First pass water was defined as flows required for sustaining a disease-free and low risk environment for fish under 3 inches in length (typically in indoor rearing). As shown, the maximum demand occurs in March for incubation and early rearing. The calculated maximum flow of 3,017 gpm can be met by the existing three well system (3,700 gpm capacity) according to our analysis (MWH 2005), and based upon the hydrogeologic field test work provided (Mayo et.al. 2004-2005). The peak well demand would only occur for a 20- to 30-day period in late spring when recharge is possibly at its highest and local irrigation well demands are low. It would also be possible to begin splitting the rainbow trout program in the inside rearing units at 2” to 2.5” and sending part of that stock to outside rearing (reuse water) to reduce the total early rearing water and pumping demand. The other species would be expected to remain inside the hatchery building system to maximize survival.

Table 3-4 provides a summary of total raceway demand. Reuse water will only be used in outside rearing (raceways, ponds, etc.), identified as a combination of early rearing (inside) water, first pass water, and serial reuse water. The maximum total demand shown is 17,509 gpm to meet the total program objective. However, this is a total flow requirement for supporting the total rearing program and does not consider serial reuse – multiple passes of the same volume of water from raceway to raceway. Serial reuse water will require reaeration/oxygenation as well as the normal expected fish husbandry requirement to remove solids and control ammonia concentrations. For a four-pass raceway serial reuse system the actual maximum demand would be approximately 4,400 gpm assuming the target Flow Index (Table 3-2). Peak rearing demand occurs in late April and declines significantly by mid May. Annual mean reuse water demand is relatively constant over seven months at approximately 6,500 to 9,000 gpm (1,625 to 2,250 gpm in a four-raceway array using serial reuse). Flows were calculated on a weekly basis based upon the biomass (fish) present at the beginning of each week. Figure 3-1 provides a graphic depiction of water use calculated by the model.

3.2 Rearing Unit Volumes

Tables 3-5 and 3-6 provide the individual number and total volume for the 60 cf (in-building early rearing) and 2626 outdoor raceway rearing units (i.e., raceways or tanks) that the model calculates as the volume required to meet the individual program requirements. This information is presented on a weekly basis. As discussed, the unit size is somewhat arbitrary and the specific volume of the two rearing units is assumed only for the model to calculate total volume and provide an indication of the space required and will be modified for conceptual design. The information provides an example of the number of individual units of that specific size, that would be required to meet the program target objectives given the stated assumptions and DWR information. Of more importance is the calculation of maximum total volume required on a weekly basis necessary to satisfy the overall program requirements. For example, using the early rearing 3” fish size holding assumption, approximately 2,220 cf of total maximum rearing volume is necessary to meet program needs. The maximum demand occurs in January through mid April then decline rapidly until the next annual cycle. This assumes no early splitting or moving of under 3” fish to outside rearing -- which is only an assumption for running the model.

Figure 3-1
Flow in gpm as Function of Day



For late rearing (grow out), a maximum total volume of 97,125 cf of rearing space would be required in late March and early April.

Figure 3-2 provides a graphical interpretation of the model's annual output for the two rearing units selected. The figure provides a representation of how the rearing volume requirements change over a propagation cycle including the carry-over from the A and G series.

3.3 Waste Discharge

Waste management in aquaculture is an issue that has the potential to limit the production capabilities of a facility regardless of water availability and physical facilities. The Midway Fish Hatchery facility has been operating under the authorization of a Utah Pollutant Discharge Elimination System (UPDES) permit issued in March of 2000. The point of discharge – Outfall Number 001 – has limits on the discharge annual concentration as well as some concentration limits. Table 3-8 provides a summary of the 2000 permit.

The Midway Fish Hatchery has used a dedicated settling pond for wastewater treatment of the combined effluent flow. Pond 5, as this facility has been identified, is a shallow open water impoundment of approximately 1.5 surface acres and has an estimated maximum volume of 7.5 acre feet (2.5 million gallons). Based upon our understanding, the wastewater system (in the past) has been capable of meeting the UPDES limits when the system was operated.

DWR has indicated that the limits in the UPDES permit will remain as shown with the exception of total net phosphorus which, as result of the Total Maximum Daily Load (TMDL) for the Deer Creek drainage, is expected to be reduced from 626 kg/year (1380 lb/year) to 400 kg/year (882 lb/year) a 36% reduction in net load from the hatchery.

Feed management, feed formulation and waste solids removal are the main options for phosphorus control that have been used by hatcheries in most western states when faced with total phosphorus (TMDL) limits. The use of low phosphorus diets, floating feeds that are better utilized by fish, and enhanced waste management can all aid in reduction of total phosphorus in the facility wastewater. The DWR currently successfully uses a low phosphorus, high energy formulated diet (feed) and has used floating feed at its other facilities. The Midway Fish Hatchery is expected to adopt and maintain these practices. Table 3-7 provides the project feed requirement that was generated by the production model.

Table 3-9 provides our model simulation program summary for the Midway Fish Hatchery. As indicated, the predicted phosphorus discharge from the target program is 685 kg/year based upon 120,019 kg of feed necessary to meet the growth and number objectives. As shown on Figure 3-3, the discharge phosphorus level is computed as a factor of the total estimated pounds of phosphorus per pound of feed (0.78% P/Feed) provided and the transformation of the phosphorus during feeding (efficiency), feed conversion biologically and waste elimination. This analysis assumed 100% efficiency in feeding (no loss of feed) for estimating purposes.

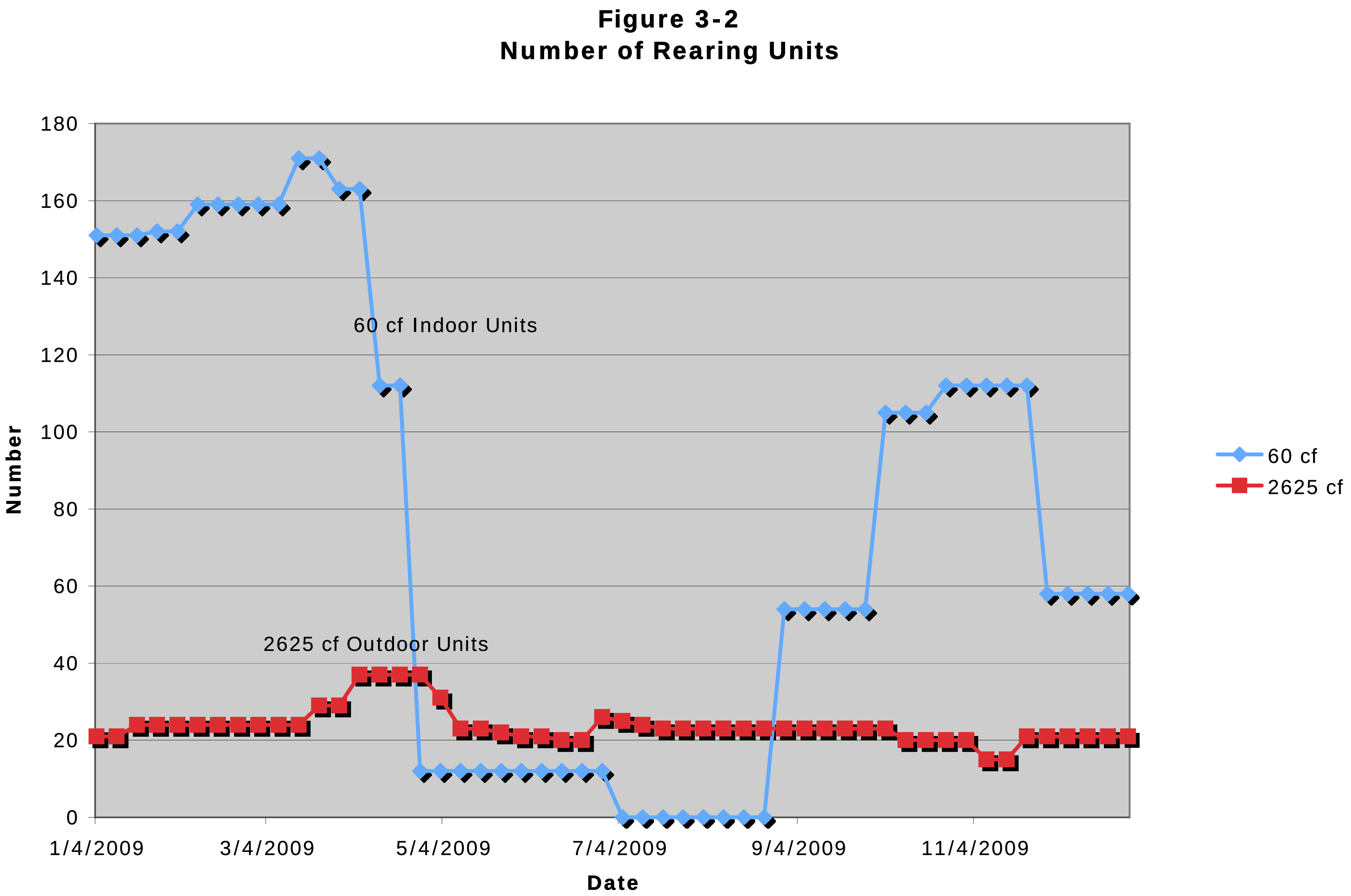


Figure 3-2
Number of Rearing Units
Number
Date
180
160
140
120
100
80
60
40
20
0
1/4/2009
3/4/2009
5/4/2009
7/4/2009
9/4/2009
11/4/2009
60 cf Indoor Units
2625 cf Outdoor Units
60 cf
2625 cf

TABLE 3-8

MIDWAY FISH HATCHERY DISCHARGE SUMMARY

Effluent Characteristics	Discharge Limitations[1] Daily Min.	Daily Max.	Yearly Max.	Monitoring Requirements Measurement Frequency	Sample Type
Flow, mgd[2]	NA	NA	NA	Monthly	Instantaneous
Dissolved Oxygen, mg/L	6.5	NA	NA	Monthly	Instantaneous
TSS, mg/L	NA	25	NA	Monthly	Grab
TSS, lbs/day[3, 4]	NA	1,398	NA	Monthly	Grab
Total P, influent, mg/L	AN	NA	NA	Monthly	Grab
Total P, Effluent, mg/L	NA	NA	NA	Monthly	Grab
Total P, net/month, kg/mo[5]	NA	NA	NA	Monthly	Calculated
Total P, net/year, kg/yr[5]	NA	NA	626	Monthly	Calculated
pH, standard units	6.5	9.0	NA	Monthly	Grab

NOTES:
There shall be no discharge of floating solids or visible foam in other than trace amounts.

There shall be no discharge of sanitary wastes or process water from fish processing operations. Only commercially processed fish feed shall be used (no unprocessed offal or other animal by-products).

Rearing of fish within the final settling pond (final waste treatment pond) is not permitted.

At least one regular sampling per year shall be taken during raceway cleaning. It shall be noted at the bottom of the discharge monitoring report in the comments section which sample was taken during raceway cleaning.

1. See Definitions, *Part 1.A* for definition of terms.
2. Flow in MGD shall be taken in conjunction with sampling of TSS.
3. See Definitions, *Part 1.A.13.* for how to calculate the pounds per day of TSS discharged.
4. Reported TSS can be a “net value” if the source water TSS concentration contributes to and/or causes a violation of effluent limits. If the Midway Fish Hatchery chooses to report a “net value” TSS, it must monitor the source water as well as the effluent.
5. The “net” Total Phosphorus contributed by the hatchery is to be monitored and reported monthly. It will be reported in terms of both the "net” contributed that month and also the “net” contributed thus far during the calendar year (year-to-date).

Table 3-9
Phosphorus Discharge Program Summary

Date	First Pass	Reuse	Date	60 cf	2625 cf	Total Vol	Date	Feed Input (lb/week)	P Discharge (lb/week)
1/4/2009	1,121	8,552	1/4/2009	151	21	64185	1/4/2009	4645	26.52
1/11/2009	1,243	8,911	1/11/2009	151	21	64185	1/11/2009	4861	27.76
1/18/2009	1,395	9,275	1/18/2009	151	24	72060	1/18/2009	5283	30.17
1/25/2009	1,177	10,142	1/25/2009	152	24	72120	1/25/2009	5550	31.70
2/1/2009	1,300	10,557	2/1/2009	152	24	72120	2/1/2009	5824	33.26
2/8/2009	1,521	10,976	2/8/2009	159	24	72540	2/8/2009	6103	34.85
2/15/2009	1,678	11,399	2/15/2009	159	24	72540	2/15/2009	6386	36.47
2/22/2009	1,855	11,825	2/22/2009	159	24	72540	2/22/2009	6767	38.64
3/1/2009	2,055	12,254	3/1/2009	159	24	72540	3/1/2009	7082	40.44
3/8/2009	2,273	12,685	3/8/2009	159	24	72540	3/8/2009	7470	42.66
3/15/2009	2,783	13,119	3/15/2009	171	24	73260	3/15/2009	7811	44.61
3/22/2009	3,017	13,554	3/22/2009	171	29	86385	3/22/2009	8158	46.59
3/29/2009	2,787	14,460	3/29/2009	163	29	85905	3/29/2009	8509	48.60
4/5/2009	2,963	14,966	4/5/2009	163	37	106905	4/5/2009	8865	50.62
4/12/2009	2,269	15,476	4/12/2009	112	37	103845	4/12/2009	8927	50.98
4/19/2009	2,423	15,989	4/19/2009	112	37	103845	4/19/2009	9280	53.00
4/26/2009	175	16,936	4/26/2009	12	37	97845	4/26/2009	8647	49.38
5/3/2009	209	17,509	5/3/2009	12	31	82095	5/3/2009	9034	51.59
5/10/2009	247	12,879	5/10/2009	12	23	61095	5/10/2009	6515	37.21
5/17/2009	287	8,119	5/17/2009	12	23	61095	5/17/2009	4396	25.10
5/24/2009	330	7,901	5/24/2009	12	22	58470	5/24/2009	4291	24.51
5/31/2009	376	7,659	5/31/2009	12	21	55845	5/31/2009	4175	23.84
6/7/2009	424	7,390	6/7/2009	12	21	55845	6/7/2009	4045	23.10
6/14/2009	474	7,096	6/14/2009	12	20	53220	6/14/2009	3902	22.28
6/21/2009	527	6,773	6/21/2009	12	20	53220	6/21/2009	3745	21.39
6/28/2009	582	6,422	6/28/2009	12	26	68970	6/28/2009	3574	20.41
7/5/2009	0	6,682	7/5/2009	0	25	65625	7/5/2009	3388	19.35
7/12/2009	0	6,331	7/12/2009	0	24	63000	7/12/2009	3186	18.19
7/19/2009	0	5,950	7/19/2009	0	23	60375	7/19/2009	2968	16.95
7/26/2009	0	5,892	7/26/2009	0	23	60375	7/26/2009	2926	16.71
8/2/2009	0	6,196	8/2/2009	0	23	60375	8/2/2009	3083	17.61
8/9/2009	0	6,504	8/9/2009	0	23	60375	8/9/2009	3242	18.52
8/16/2009	0	6,815	8/16/2009	0	23	60375	8/16/2009	3403	19.44
8/23/2009	0	7,130	8/23/2009	0	23	60375	8/23/2009	3566	20.37
8/30/2009	183	7,448	8/30/2009	54	23	63615	8/30/2009	3731	21.31
9/6/2009	183	7,768	9/6/2009	54	23	63615	9/6/2009	3897	22.26
9/13/2009	183	8,090	9/13/2009	54	23	63615	9/13/2009	4065	23.21
9/20/2009	221	8,414	9/20/2009	54	23	63615	9/20/2009	4234	24.18
9/27/2009	284	8,740	9/27/2009	54	23	63615	9/27/2009	4544	25.95
10/4/2009	541	9,066	10/4/2009	105	23	66675	10/4/2009	4751	27.14
10/11/2009	617	9,394	10/11/2009	105	20	58800	10/11/2009	4964	28.35
10/18/2009	700	7,875	10/18/2009	105	20	58800	10/18/2009	4362	24.91
10/25/2009	1,011	8,201	10/25/2009	112	20	59220	10/25/2009	4581	26.16
11/1/2009	434	9,230	11/1/2009	112	20	59220	11/1/2009	4870	27.81
11/8/2009	460	9,663	11/8/2009	112	15	46095	11/8/2009	5108	29.17
11/15/2009	397	5,928	11/15/2009	112	15	46095	11/15/2009	3066	17.51
11/22/2009	453	6,243	11/22/2009	112	21	61845	11/22/2009	3310	18.90
11/29/2009	512	6,566	11/29/2009	58	21	58605	11/29/2009	3501	19.99
12/6/2009	574	6,896	12/6/2009	58	21	58605	12/6/2009	3696	21.11
12/13/2009	638	7,232	12/13/2009	58	21	58605	12/13/2009	3896	22.25
12/20/2009	704	7,575	12/20/2009	58	21	58605	12/20/2009	4101	23.42
12/27/2009	773	7,923	12/27/2009	58	21	58605	12/27/2009	4309	24.61
Total (lbs)								264593	1511

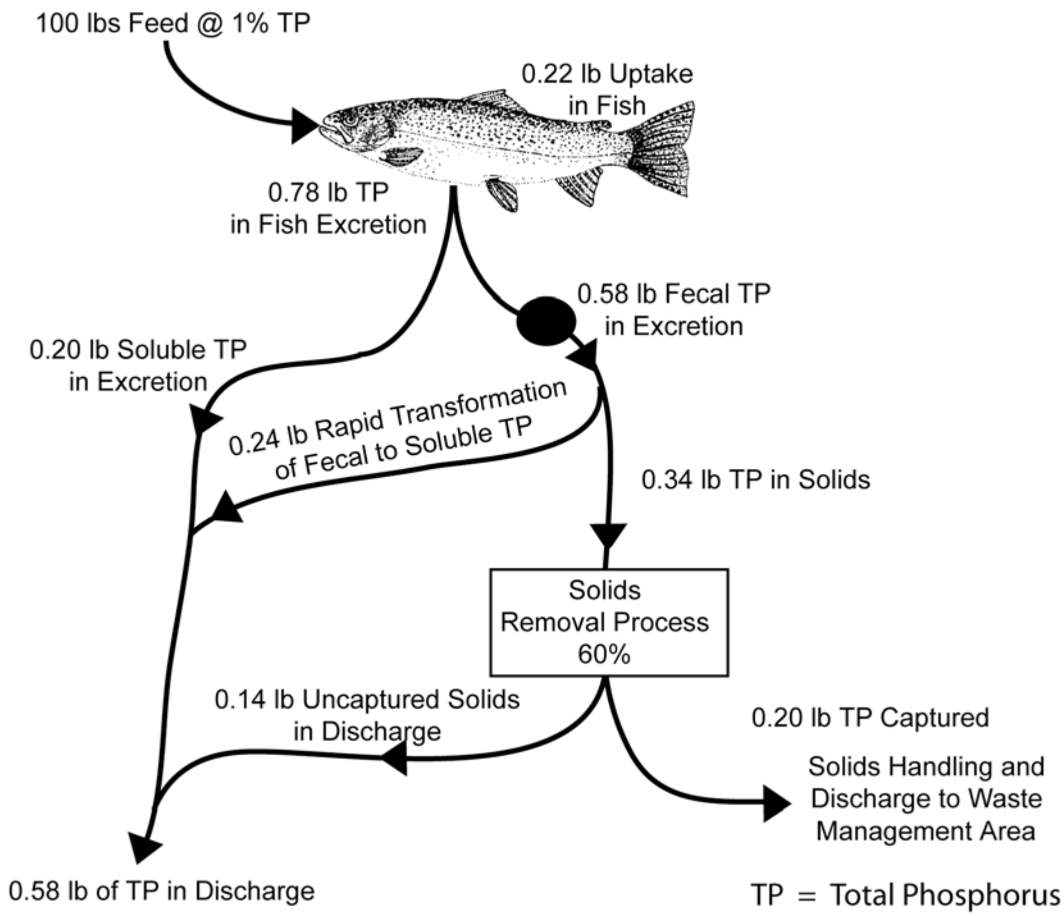


Figure 3-3
Feed Conversion of Phosphorus Generation Mass Balance For A Conventional Sports Fish Hatchery

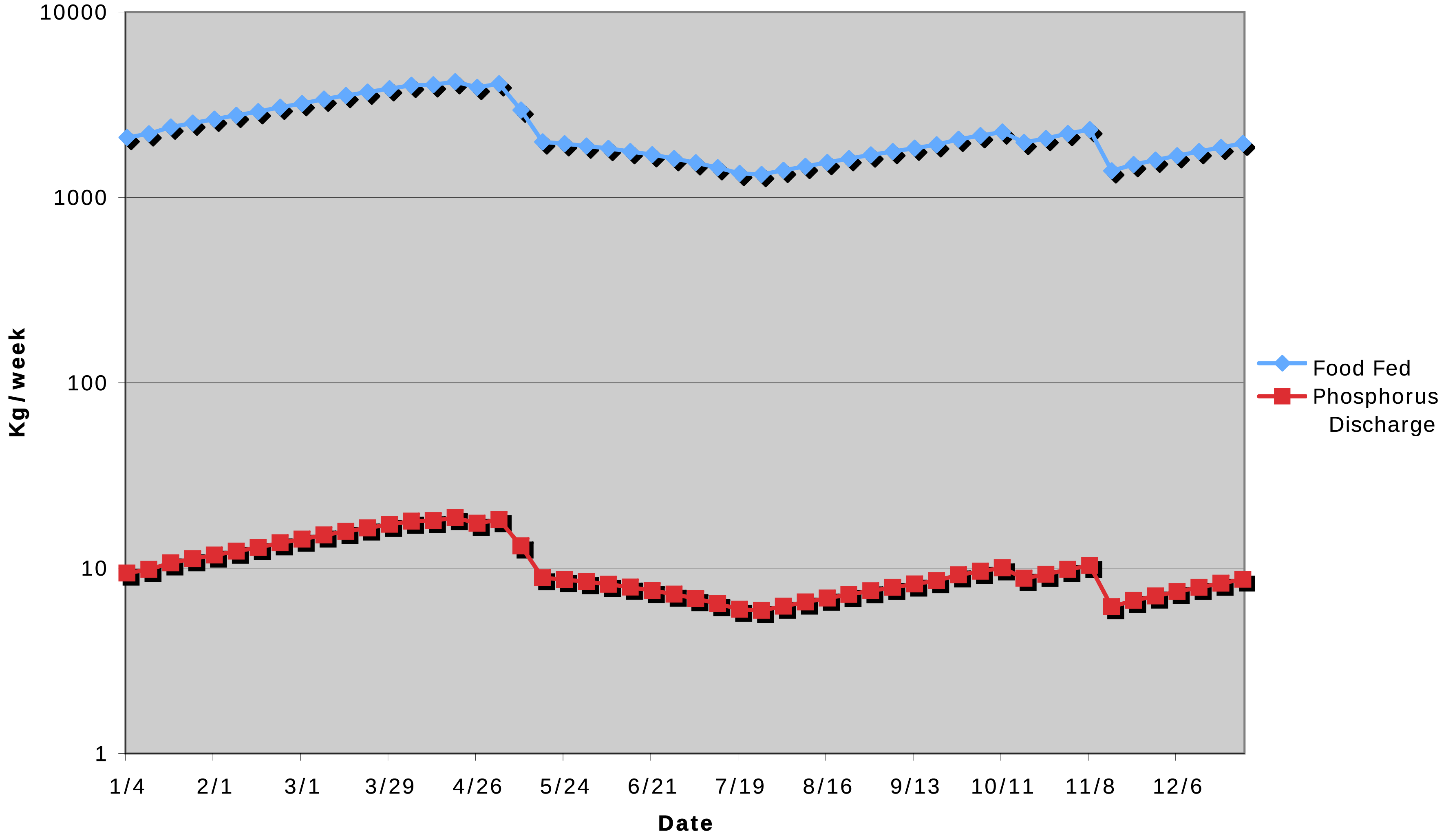
Figure 3-4 presents a graphical representation of total feed input to total phosphorus discharge on a weekly basis for an annual cycle.

Based upon this analysis, the discharge of phosphorus from the feed source alone, on an annual basis (685 kg/year), would exceed the 400 kg/year UPDES anticipated reviewed standard by 285 kg/year or by 71 percent.

The approach that the model uses to calculate TP loading is the traditional method used by most sports fish hatcheries to manage waste solids and is not designed specifically to address phosphorus. A second issue that must be considered with regards to Midway Fish Hatchery's discharge of phosphorus, is that the current discharge permit adjusts for the background TP present in the spring water by only assessing the hatchery for the "net" increase in TP that the rearing activities of the hatchery add to the effluent discharge.

The Kamas Fish Hatchery provides a realistic model for assessing the level of TP that could be discharged from a modern DWR hatchery. The new Midway facility and the Kamas Hatchery

Figure 3-4
Feed Input and Total P Discharge



will be designed using similar (not necessarily identical) facilities and waste management processes and be operated in a similar manner

The Utah Department of Environmental Quality, Division of Water Quality (UDWQ) has sampled and measured phosphorus and flow in the inflow springs and the hatchery outflow at Kamas. These data are stored in the U.S. Environmental Protection Agency (EPA) STORET database and are accessible via the Internet. The data analysis includes calculating flow-weighted concentrations by summing the product of flow and concentration from each sample date, then dividing by the sum of the flows. The resulting flow-weighted concentration is multiplied times the average flow and appropriate conversion factors are applied to compute the phosphorus load. The net phosphorus load is computed by subtracting the inflow load from the outflow load. The net phosphorus load (mass) is then divided by the hatchery fish production (mass) to yield a unit phosphorus mass produced per unit fish mass (lb/lb or kg/kg).

The inflow water quality and flow data are from two springs, East Springs (STORET Station #4929020) and North Springs (STORET Station #4929030). The flow-weighted total phosphorus (TP) concentration is 0.023 mg/L from a total spring inflow of 1750 gallons per minute (gpm). This flow-weighted TP concentration is the same as provided to UDWR from UDWQ data collected in the 1980s and 1990s. The East and North spring flows are combined to form one inflow stream to the hatchery. The inflow rate is assumed to equal the outflow rate for purposes of computing the inflow load. The mean outflow rate is 1,950 gpm (n = 25) during the period from 2001 through 2005. Therefore, the inflow estimated TP load is 91-kg/year. The flow-weighted dissolved phosphorus (DP) concentration is 0.010 mg/L, with an inflow estimated DP load of 39-kg/year. It should be noted that the computed load values are based on one set of samples recorded in the STORET database from one date, and subsequent use of these estimated loads assumes that the mean groundwater inflow rate and measured phosphorus concentrations are representative of actual conditions (Note: in this system if the analysis is correct the actual TP should be relatively stable).

The outflow water quality and flow data are reported in the STORET database (Station #4929000). Several reported concentrations showed higher DP than TP on the same date or a TP concentration an order of magnitude higher, and these data were not considered in the analysis. The flow-weighted TP concentration is 0.091 mg/L with a mean total hatchery outflow of 1950 gpm (n = 25, standard error = 408 gpm). The calculated TP load in the hatchery outflow is 354 kg/year. The flow-weighted DP concentration is 0.054 mg/L, with a calculated outflow DP load of 208-kg/year.

The net TP load from Kamas Fish Hatchery is calculated at 263-kg/year (outflow TP load of 354-kg/year minus inflow TP load of 91-kg/year). The net DP load from the hatchery operation is calculated at 169-kg/year (total DP load of 208-kg/year minus inflow DP load of 39-kg/year). The net DP load indicates the conversion of feed to DP excreted as fish waste and DP transformed from solids collected at the end of each raceway. DP as a percentage of TP is about 64.3 percent, based on the water quality and flow data.

The annual net TP per fish mass production factor is calculated at 0.00430-kg TP/kg fish. The annual net DP per fish mass production factor is calculated at 0.00276-kg DP/kg fish. The mean annual fish production at Kamas Fish Hatchery is approximately 1,489,000 fish per year. An annual net TP per fish production factor is calculated at 0.000177-kg TP/fish. The annual net DP per fish production factor is calculated at 0.000114-kg DP/fish.

The projected net annual phosphorus loads discharged from the Midway Fish Hatchery can be compared to the unit values calculated using the results of the Kamas Fish Hatchery data analysis. These projections incorporate several important assumptions: 1) Midway Fish Hatchery will have the same basic features and operation as the Kamas Fish Hatchery; 2) the operational efficiencies at Kamas Fish Hatchery can be achieved at the Midway Fish Hatchery; 3) the same low phosphorus feed would be used at Midway Fish Hatchery; and 4) solids (fish waste, unused food, and other solids) collected at the end of each raceway will be effectively settled and regularly removed through an under-drain system for de-watering and ultimate disposal off-site in an approved landfill or composting facility.

Table 3-2 (Biological Program Modeling) shows that Midway Fish Hatchery is programmed to produce a maximum 198,442 pounds of fish (89,993 kg) per year. Using this more empirical method of analysis, the Midway Fish Hatchery projected net annual TP load would be 387-kg TP/year (89,993-kg fish per year times 0.00430-kg TP per kg fish). The 387-kg TP/year value is probably the most appropriate approach to use in TP load projections, and would be within the net 400-kg TP/year limit imposed by the TMDL TP budget for Deer Creek Reservoir. Therefore, it appears that the projected Midway Fish Hatchery operations could discharge less than the net 400 kg TP/year with a small safety factor(13-kg per year) to account for potential minor operational differences and other factors. This calculation is within the accuracy of the method used.

The projected TP load discharged from the Midway Fish Hatchery property includes 387-kg TP/year from feed and fish waste, 232-kg TP/year from the inflow at the spring (not used in production), and up to 147-kg TP/year from the deep well flow production water. Therefore, the projected TP load at the point of discharge would be approximately 766-kg TP/year. The net TP load should be calculated by subtracting the inflow load of the two sources (379-kg TP/year) from the discharge load.

3.3.1 Interpretation of Projected and Modeled Total Phosphorus Loads. The projected net TP load of 387-kg TP/year from the Midway Fish Hatchery, based on Kamas Fish Hatchery operational and monitoring data, is about 43 percent lower than the net TP load of about 685-kg TP/year calculated by the biological model programming. This is approximately 0.00761-kg TP/kg fish, which is about 1.6 times the empirical results reported for Kamas Fish Hatchery. The two TP load values can be considered extremes and the Midway Fish Hatchery will produce a TP load within the range defined by the extremes. The projected net TP load of 387-kg TP/year represents a well-operated hatchery, with highly efficient conversion of feed mass to fish mass (1.0) and twice-weekly removal of solids from the end of each raceway. The conventional biological TP hatchery model program yields a net TP load of about 685-kg TP/year and represents a conservative estimate, assuming a 1.1 to 1.2 feed conversion ratio and 1.0 percent TP in the feed. The modeled feed mass consumption to fish mass ratio for a complete year of production is about 1.34-kg feed to 1.0-kg fish because of ongoing mortality at various fish stock life stages and because the older, larger fish consume more feed than the average size hatchery fish. The model assumes 22 percent incorporation of TP by the fish and solids removal resulting in 20 percent TP removal after 40 percent rapid fecal transformation of 58 percent fecal conversion of feed utilized by fish. Operation of the Midway Fish Hatchery (at full production) would be closer to the way that Kamas Fish Hatchery is currently operated and would result in an annual average net TP discharge of approximately 400-kg TP. However, achieving about 400-kg TP/year net discharge is not an option given the TMDL limit of 400-kg TP/year net discharge. An additional amount of TP removal must be accounted for in the hatchery design and operation to make sure the net discharge will not exceed the TMDL limit of 400-kg TP/year.

Total phosphorus removal options considered for the Midway Fish Hatchery include additional solids removal using enhanced clarification and chemical addition (iron or alum) to bind the phosphorus for removal by settling, the use of constructed wetlands to remove phosphorus from the supernatant recovered from the solids removal process during the periods of the year when TP uptake is possible, or some combination of these removal options. The overflow water (containing DP) from the 400 series raceways should be conveyed beyond Pond 5 and discharged directly upstream of the pond outlet. The phosphorus removal should focused on the solids and water removed from the end of each raceway (20 to 36 percent of the TP during cleaning). In general, a higher concentration of total phosphorus in the solids and supernatant (water separated from the solids) will result in more efficient TP load removal using subsequent treatment processes (physical, chemical, and/or constructed wetlands).

Section 4

SECTION 4

CONCEPTUAL DESIGN AND LAYOUT OF MIDWAY HATCHERY FACILITIES

4.0 INTRODUCTION

There are two types of rearing units and a number of ancillary and support facilities that will be included in the new Midway Hatchery. These include, but are not limited to, the following individual structures and infrastructure facilities:

- Hatchery Building including:
  - Early rearing
  - Incubation
  - Garage and vehicle storage
  - Administrative offices
  - Staff and visitor restrooms
  - Storage (dry and wet)
- Outdoor Rearing Area
  - Covered raceways
  - Water handling and raceway cleaning
  - Oxygenation
- Water Supply and Treatment
  - Wells and controls
  - Pipelines and appurtenances
  - Degassing and oxygen addition facilities
- Wastewater Treatment
  - Solids removal, treatment and disposal
  - Pipelines and appurtenances
  - Ponds and wetlands
  - Effluent quality and discharge
- Support and Infrastructure Facilities
  - Line power and communication
  - Standby power generation
  - Access and roadway (new and existing)
  - Existing electrical power lines and conflicts
  - Visitor parking and facilities
  - Stocking trucks wash and fill
  - Liquid oxygen storage
  - Landscaping
  - Volunteer support facilities (trailers and wash facilities)
  - Replace older residence (conflicts with site)
  - Culinary water and wastewater disposal

We have not made any recommendations on the use of the old hatchery building or the new "experimental program" metal building except to provide access. The future use and eventual fate of these structures need to be discussed and resolved by DWR as part of a future program.

4.1 Rearing Units

The production model calculated that the two rearing units (excluding incubation) for early and final rearing required the following total maximum space (volume):

Early Rearing	-	10,260 cubic feet (cf)
Final Rearing	-	97,125 cubic feet

These numbers are flexible and are guidelines based primarily upon DWR direction, MWH experience and typical industry experience. The actual facility size will be a function of the final available budget for the project and the physical and regulatory limitations of the site.

As indicated in MWH's Agreement with DWR/DFCM to design the new Midway Hatchery Facility, the DWR would like to standardize, as possible, the Midway Fish Hatchery Facility with the rearing units used for the Kamas, Fountain Green and Whiterocks Hatcheries. The individual early rearing units (inside rearing units) for these facilities were approximately 840 gallons (122 cf) (total volume - 12 ft long x 3.5 ft wide x 3.3 ft in depth) insulated fiberglass troughs. Approximately 25%± of the total volume is unusable (90± cf of actual usable capacity) for rearing due to losses incurred as a result of inlet and outlet screening and depth variation.

If a maximum of 10,260 cf of actual early rearing space is required to satisfy the program demand, then 114 cf troughs would be required. This large number of troughs is not a realistic number of units and reflects the calculated conservatism of the model which does not account for splitting groups of fish or moving fish to outdoor rearing prior to reaching the exact three inch length objective.

Table 4-1 provides an analysis of three recent DWR hatcheries that have been modeled similarly to the Midway Fish Hatchery and the facilities and identifies the facilities projected by the model to meet the program requirements and the facilities have been or are currently being constructed. As shown, each of these facilities were finished with an approximate 25-50% variation in the rearing area that was projected by the model as the volume required to satisfy the program needs. However, both Kamas and Fountain Green are being operated in a very intensive manner and the model predicted design production capacity of these facilities has been exceeded on a continuous basis.

There are several reasons why the calculated volume in the model was not implemented for each of these projects. The primary reasons include:

- Cost and budget limitations
- Space restriction and limitation
- Subjective DWR determinations that the program goals could be met with less rearing space required
- Water supply limitations

TABLE 4-1

COMPARISON OF BIOLOGICAL MODEL PROGRAMMING

	Program Objective		Model		Actual Provided		Early Rearing	Rearing
Hatchery	**Production (lbs)**	**No. Fish**	**Early Rearing**	**Rearing**	**Early Rearing**	**Rearing**	**Δ -**	**Δ -**
Kamas	143,996	1,959,400	4,800 cf	52,200 cf	3,369 cf (30)	39,480 cf	-31%	-25%
Fountain Green	102,506	1,758,500	6,720 cf	32,000 cf	3,369 cf (30)	45,000 cf	-50%	+40%
Whiterocks	131,047	3,119,731	8,940 cf	59,025 cf	4,717(+) cf (42)	36,730(+) cf	-47(+)%	-38(+)%
Midway	198,442	2,099,000	10,260 cf	97,125 cf	TBD	TBD	---	---

+ Future space outside provided for late early rearing
(480 cf) units installed

4.1.1 Indoor Early Rearing. Both the Kamas and Fountain Green Hatcheries are exceeding their production goals, but staff reports that additional indoor incubation and early rearing capacity would be desirable. As proposed, the Whiterocks Fish Hatchery will have approximately 30 percent more early rearing tank volume when completed with a future provision to add protected outdoor tanks near the building for additional late early rearing (prior to the raceways). The incubation area is essentially the same as the two other facilities.

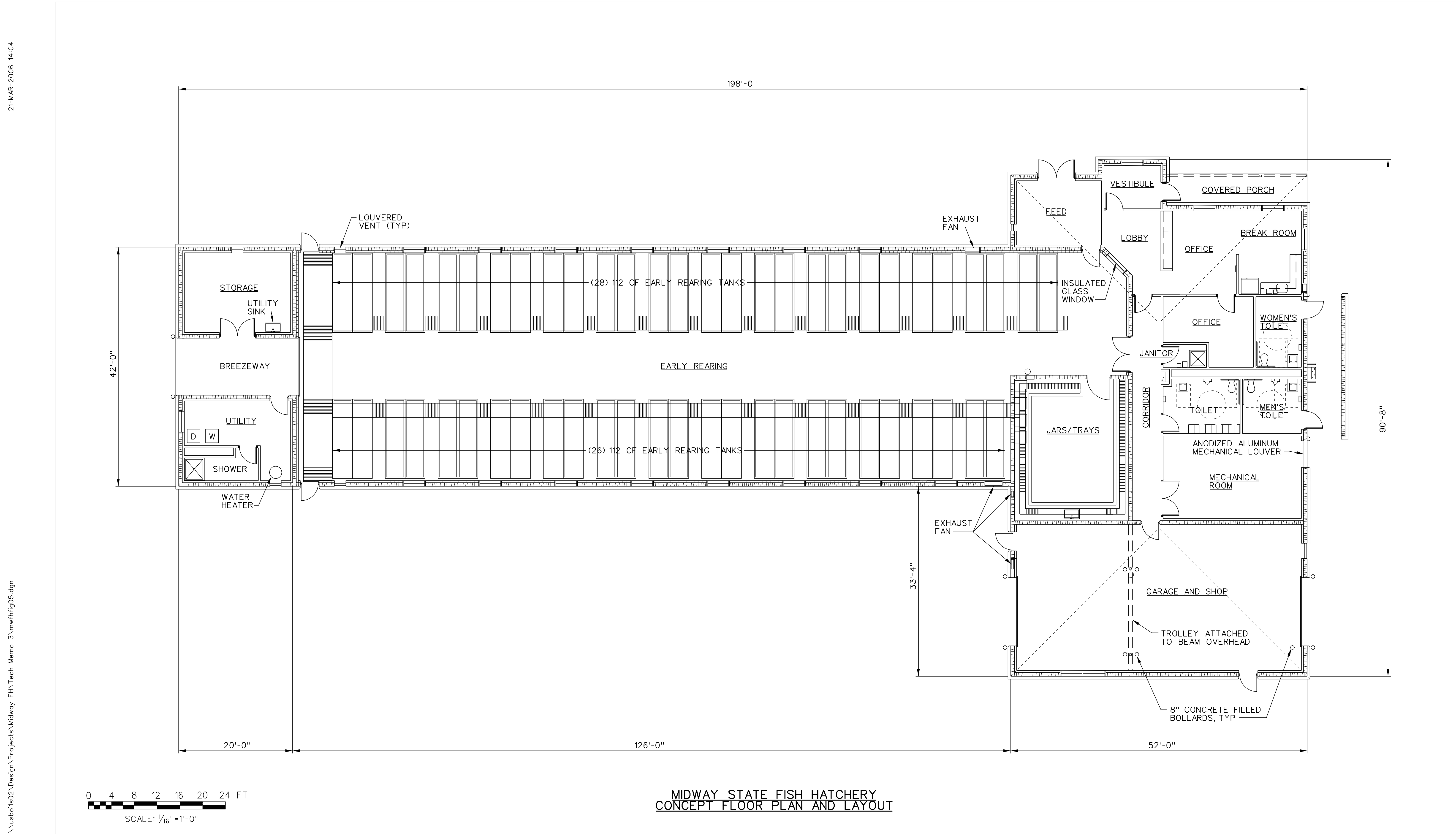
The Midway Fish Hatchery model calculated that the early rearing requirements would be approximately the same as the Whiterocks Fish Hatchery. Based upon the discussions at the Conceptual Design Workshop (No. 2), it was concluded that the Midway Hatchery would require a larger incubation area (approximately 33 percent additional space was selected as a target, based upon DWR general direction) and that the early rearing area should include capacity for a minimum of 54 100-110 cubic foot (effective) insulated early rearing tanks (5,400 - 6000 cf total effective volume). Each tank will be planned to have a maximum single-flow flow of 40 gpm (2,080 gpm total plus a total flow of 150 gpm for incubation and other functions – 2,230 gpm total incubation and early rearing flow) of degassed and oxygenated (potential) well water. Figure 4-1 provides the preliminary layout of the conceptual hatchery building that will provide the proposed facilities and capacity. The early rearing volume, used in this design, can be adjusted to satisfy the project available budget requirements by lengthening or shortening the rearing area. By using a linear configuration for the early rearing area, the space is effectively used, operational access is provided and changes in final size can easily be accommodated without having to significantly alter the overall structural design. If sufficient funding is available and the site layout is appropriate, the indoor rearing area could be expanded using the elongated building design proposed. The proposed concept design allows for 54 troughs and approximately 500 ft^2 of incubation room space.

The building would be similar construction to earlier DWR hatchery facilities designed by MWH. Construction would be durable masonry block on a concrete foundation. Drain piping and other infrastructure would be carried in subsurface grated trenches to keep the work space free of obstructions. The early rearing feed storage room would be provided with a stainless steel work table with a sink and water supply (staff requested). Two visitor toilets and one staff toilet would be provided. The visitor toilets will have only exterior access. Storage and administrative staff areas will be similar to Fountain Green and Kamas. The garage area will be slightly smaller than the previous two hatcheries (>60 ft^2) in order to accommodate the larger incubation area. However, the new metal building (currently used for experimental cutthroat trout rearing) can be converted to closed vehicle storage if desired.

The building program would include the space shown in Table 4-2.

The garage would have a drive-through bay with a hoist beam for removing heavy objects.

The early rearing room would have a single, center, overhead door (12’ x 10’) suitable for small vehicles.



Midway State Fish Hatchery
Concept Floor Plan and Layout
Figure 4-1

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TABLE 4-2

BUILDING PROGRAM MIDWAY FISH HATCHERY

Room No.	Room Name	SF Area
101	Vestibule	112
102	Lobby	126
103	Feed Storage	224
104	Office	219
105	Break room	207
106	Janitor	107
107	Storage	112
108	Women's Toile	132
109	Men's Toilet	131
110	Staff toilet	147
111	Mechanical Room	399
112	Garage Shop	1,420
113	Corridor	225
114	Jar/Tray Room (Incubation)	500
115	Early Rearing	5,638
	TOTAL	**9,700**

The incubation room would include a large stainless steel sink with both hot and cold culinary water and a combination eyewash/drench shower for safety. No fire sprinkler system is proposed due to the type of construction, however, fire extinguishers and fire alarms (smoke detectors) will be provided.

The roof would be standing seam metal (30-year roof). The walls in rearing and incubation rooms would be furred out (where appropriate), insulated and covered with sealed water-resistant fiberglass panels. Ceilings would vary from room to room by including both acoustical panels in administrative areas and epoxy coated gypsum board in rearing areas.

The rearing space would be ventilated to maintain a 50 percent maximum humidity and heated to 65°F. The administrative area would have independent temperature control for human comfort.

The area around the building would be asphalt paved and graded to allow runoff control (Figure 4-2).

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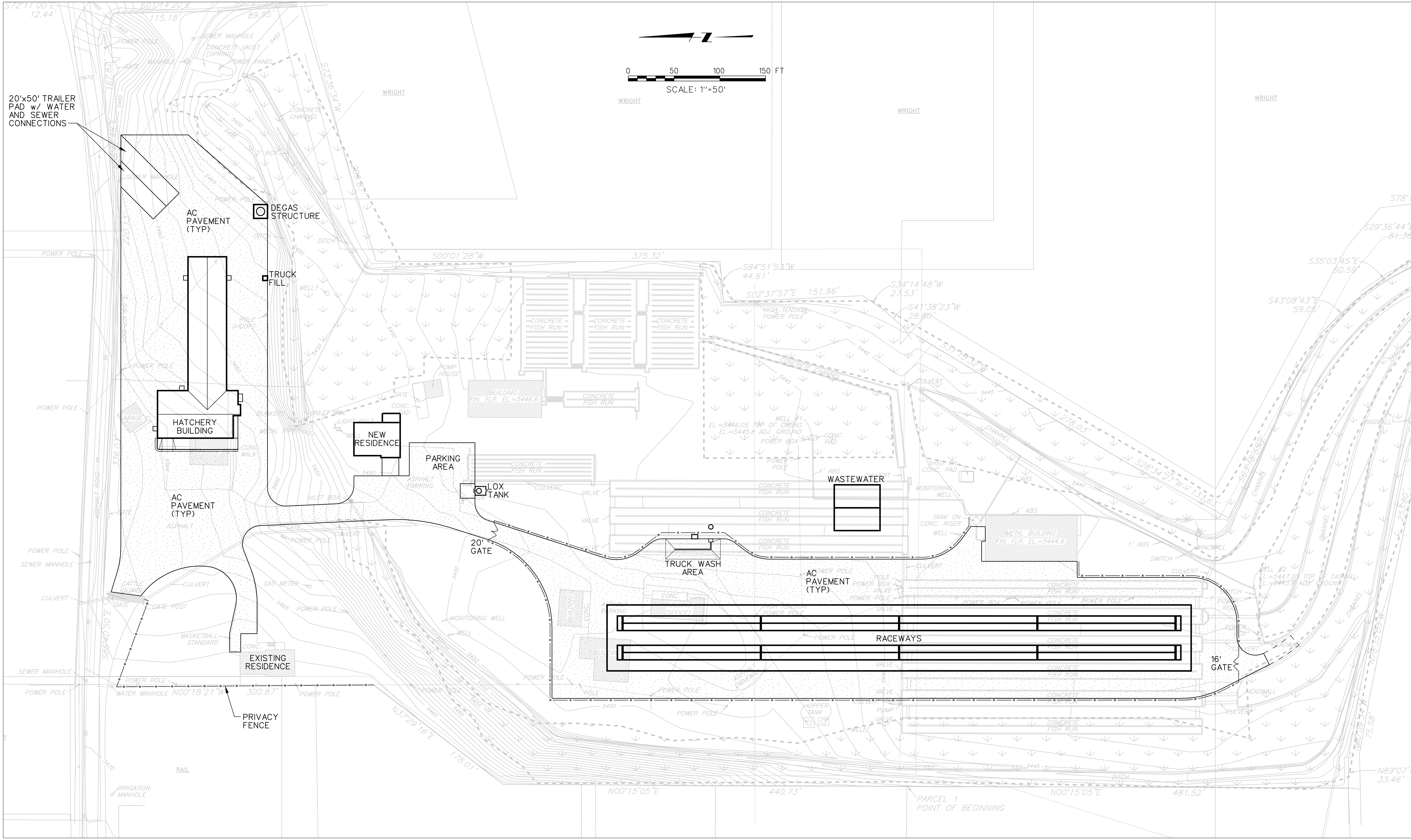

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Midway State Fish Hatchery
Site Plan
Figure 4-2

4.1.2 Outdoor Final Rearing. Outdoor rearing was assumed to be in raceways and raceways are to be covered to minimize the introduction of disease. The model calculates that a total maximum raceway volume of 97,125 cubic feet was required. Again, this assumes a dedicated space for each program and no splitting of lots of fish, as space becomes available due to outplanting, or the release of any fish prior to the exact program target size is reached, a sound idea but probably not a realistic assumption.

Table 4-3 provides an analysis of the raceway rearing units design criteria used at the three new hatcheries. Both Kamas and Fountain Green use a 6.25 ft wide raceway that facilitates baffle and screen placement and removal. At Whiterocks a wider (8 ft) units were necessary due to site limitations and environmental issues.

TABLE 4-3

RACEWAY UNIT COMPARISON

Hatchery	No.	Width	Available Length	Operating Depth (SWD)	Total Individual Unit Volume	Total Volume
Kamas	16	6.25 ft	138 ft	3 ft	2,589 cf	41,424 cf
Fountain Green	16	6.25 ft	142 ft	3 ft	2,663 cf	42,608 cf
Whiterocks	12	8 ft	127.5 ft	3 ft	3,060 cf	36,720 cf

Based upon discussions with the DWR staff regarding operation of raceways at Kamas and Fountain Green Hatcheries and the limited area available at the two candidate Midway Fish Hatchery raceway sites (upper and lower areas), the DWR selected a 6.5 ft wide raceway with an overall length of approximately 150 ft for the Midway Fish Hatchery.

The design and layout of the raceway units must be balanced between providing sufficient space based upon fish density, provide enough water flow to both support fish propagation and maintain a relatively self-cleaning unit, maintaining gravity flow through the serial reuse units, providing reasonable operational access and meet cost constraints which is a function of budget and site conditions. Since the Midway raceways must be covered to avoid introduction of disease, this will add extra issues, both in terms of the site conditions and limitations (size, power relocation, geotech, regulations, etc.) and cost.

The well water supplies for the facility (first pass) is limited to approximately 3,700 gpm (Mayo 2003-2005) or 8.2 cfs. The available degassed and oxygenated water will be used as first pass in the hatchery building of incubation and early rearing. The building effluent (reuse water) and the excess first pass water will be conveyed to the raceway area in separate pipes. First pass water will be delivered to the first set of four raceways (100 series) and reuse water will have the capability to be used in either the 100 series or 200 series raceways.

Flow is critical to carry oxygen to support fish development, maintain the necessary rearing environment and remove both dissolved and solid waste from the rearing system. Assuming that the new raceways will have hinged movable baffles (as per earlier similar projects) for solids management, we have made the assumption that the maximum bottom baffle deflection will not exceed one-foot of open space (range 3 inches to 12 inches). In theory it would be ideal to maintain a flow necessary to achieve a velocity of 0.3 - 0.5 ft/sec to provide effective scouring velocity along the bottom of the raceway. This is typically a conservative assumption given the lighter density of the fish waste material and the ability for solids to be moved at much lower velocities due to the action of flow and current generated by the movable baffle system and fish movement. From earlier studies it was established that a minimum velocity of approximately 0.1 ft/sec will need to be maintained in the bottom portion of the raceways (under the baffle) for effective movement of solids.

Two site options for locating the raceways were considered. These were identified as the lower and upper site. The lower site would be developed at the current location of Ponds 4 and 5. This location was initially determined to be "waters of the nation" and natural (but constructed) wetlands by the Corps of Engineers (Corps), based upon MWH initial discussions with the Corps in early January (2006). Since the two ponds were originally developed for fish rearing and wastewater treatment, this determination may not be valid. However, the main interest DWR staff had with this site was the potential to provide well water by artesian flow part of the year. Based upon the recent survey information and our analysis of the artesian available head, it was determined that the wells could not provide the artesian flow required, at sufficient head, to provide lift to a degassing structure for this option to be feasible. Given the complicated wetland issue and the probability of a long regulatory delay if the lower pond location was selected; the limited size of the site; and the apparent inability to meet the practical hydraulic requirements using artesian flow, this site was not carried forward in this analysis.

A second option, the upper site, was examined using a four-pass serial raceway (four common-wall paired units) array (16 unit configuration) to best utilize the available space. This would provide approximately 46,800 cubic feet (gross) of rearing capacity. The calculated bottom velocity (maximum baffle deflection) would be approximately 0.31 ft/sec. Thus, assuming maximum well flow and an equally divided raceway flow split between the four sets of raceways. This series configuration allows an elongated raceway structure and cover to the raceway (approximately 68 ft x 650 ft overall). The elongated configuration will help reduce the cost of the cover structure.

For this option (Figure 4-3), we are assuming that a large center access driveway between each pair of raceways, with roll-up truck doors, is provided at each end of the structure for access by a large tank truck (16 ft vertical clearance). The peripheral raceway of each pair can be accessed by a 10-ft wide aisle with roll-up doors. We have assumed that a metal building type of structure with 4 in 12 pitch metal roof would be constructed over the area. The enclosure would include a 24- to 36-inch masonry or concrete pony wall above the foundation topped with metal siding up to within 2-3 ft of the eave height with 1-inch galvanized screen above the siding to allow for ventilation and prevent wildlife access. No insulation or mechanical ventilation would be provided. LHO units and oxygen supply lines would be provided to all raceways. Lighting and 110-220 volt electrical power (GFA outlets with covers) will be included in the center drive areas and/or along the walls.

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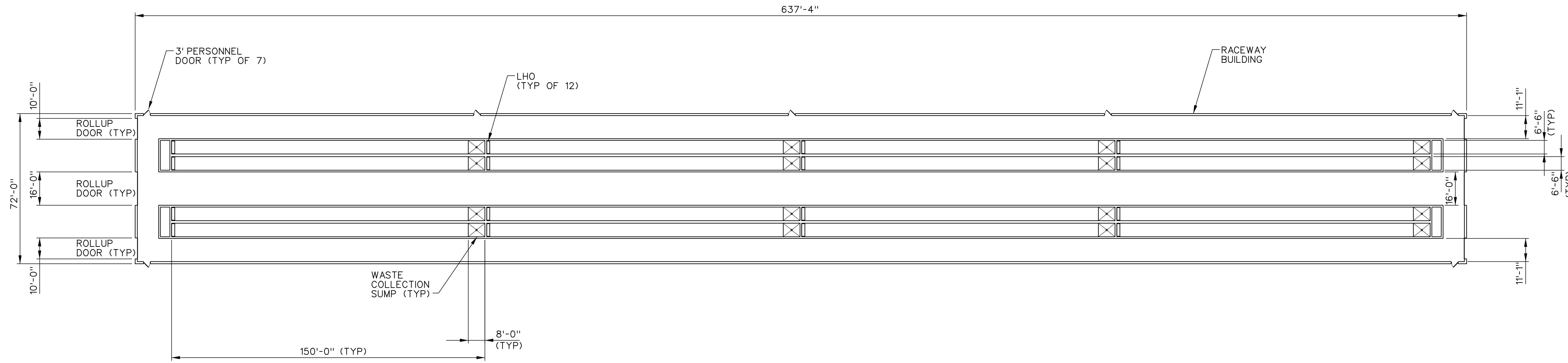

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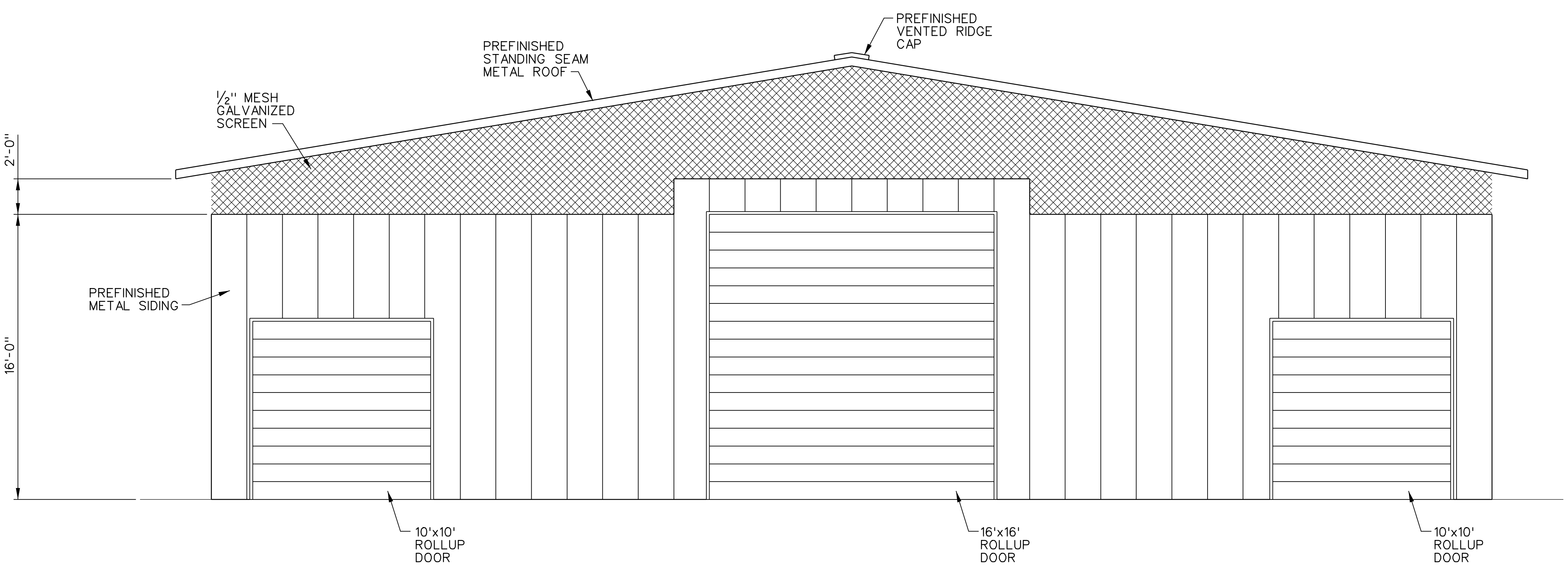
RACEWAY PLAN



NORTH ELEVATION

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Midway State Fish Hatchery
Covered Raceway Layout
Figure 4-3

4.2 Proposed Preliminary Site Layout

Two physical locations have been identified for the primary hatchery facilities. The hatchery building would be located at the upper bench area, near the existing older residence. The raceway structure would be located in the upper bottom area in a north-south configuration (Figure 4-1).

4.2.1 Raceways and Covered Structure. Due to the concern regarding disease in the spring flow and shallow groundwater, several options were considered for insuring that the raceways would not be subject to infiltration of potentially contaminated (disease issue)groundwater. The most realistic options considered included:

- Maintaining the bottom of the raceways significantly above the existing shallow groundwater (groundwater is 2-5 ft below surface according to geotechnical report but experience indicates that groundwater can be within a few inches of the surface at some times of the year).
- Providing a flexible membrane liner (FML) around the raceway units and partially burying the units at or near groundwater to reduce hydraulic pressure.
- Using fiberglass raceways constructed above grade on a concrete foundation.

Following the conceptual planning workshop and a number of subsequent discussions with DWR staff, it was determined that raising all the raceways above grade (shallow groundwater) would be very expensive in terms of the volume of fill that would have to be imported. Based upon quotes from a local (Heber City) quarry, material delivery and placement cost for structural fill would be in the range of \$20-\$25 cy. The total estimated (preliminary) cost for fill and placement would be approaching \$750,000.

The use of fiberglass raceways in the size required was considered, but due to the site issues and the need to both provide a concrete base and possibly short lateral support walls to contain the fiberglass structures and the high cost for purchasing and installing suitable units, this option was not considered further.

The use of an external HDPE liner that would surround each pair of raceways was investigated with the assistance of a manufacturer of a physically bonded concrete external liner system. The manufacturer estimated that the material installed by a qualified contractor would be approximately \$10/ft^2. Assuming a full height wrap of the raceways and approximately two foot of burial (above the measure level in the geotechnical report), the total cost of lining system for raceways would be in the range of \$250,000 - \$350,000.

The material considered would consist of a 2.0 mm liner using a concrete embedment system (Photo 4-1). This system bonds the liner into the exterior concrete wall. When the concrete form work is removed, the external structure is encased in a HDPE membrane. Seams are thermally welded using a deposition type plastic welding machine. The seams can be vacuum tested to determine the continuity of the weld.

Based upon detailed discussions with DWR, it as concluded that due to the disease concerns and the lack of experience using a liner system, that maintaining the bottom of the raceway above the existing grade (shallow groundwater) was the preferred way to proceed.

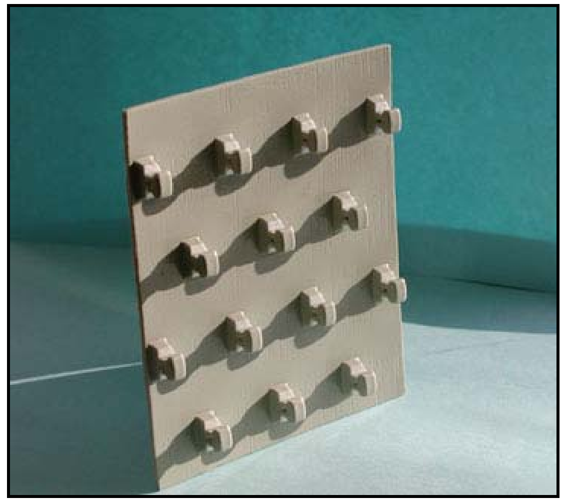

Photo 4-1
Concrete Stud Liner

The location of the raceways would require the demolition and removal of the existing hatchery administration, storage and vehicle building as well as the western most raceways (Figure 4-4). The location would protect the area at the far western edge of the DWR property identified as wetlands (MWH 2005 Wetland Delineation). The south end of the raceway building would be provided with a turn-around area for the larger tanker trucks that would access the center aisle of the building. We have conceptually located a truck wash and fill site at the north end of the raceway with runoff and drainage control to keep any contaminated water from running into the raceway area. However, this facility could also be located at the upper area closer to the hatchery building. A second truck fill facility is located near the building.

The lower rearing area would be fenced to include the existing metal building and the raceway building secured with locking doors.

Assess to the lower area, wells PW-2 and PW-3 and the new metal building would be provided by a upgraded gravel road.

4.2.2 Hatchery Building. The location of the hatchery building was discussed and evaluated. Two general concerns arose regarding the building location. The first was the given need and cost to pump well water to a new degassing unit and the second was the possible need to pump hatchery building effluent reuse water to the raceways. The use of pumping, while necessary for the well water supply at the Midway Fish Hatchery, is generally discouraged for hatchery operation due to reliability concerns and cost.

Two hatchery building locations were initially identified. The first was located near the east side of the initial set of the proposed new covered raceways. This was identified as the lower area. It allowed the hatchery building and raceways to be on essentially the same level. The problem with this site was that unless the hatchery building was constructed significantly higher on imported fill than the raceways (5 to 6 ft), it would not be possible to introduce reuse water into the low head oxygenators (LHO) (to be used for oxygenation in raceway series 100, 200 and 300) by gravity. Reuse water would need to be pumped.

The second site (Figure 4-2) was located on the upper bench (upper-upper site) adjacent to the hatchery entrance and would require the development of a new residence. The older (eastern)

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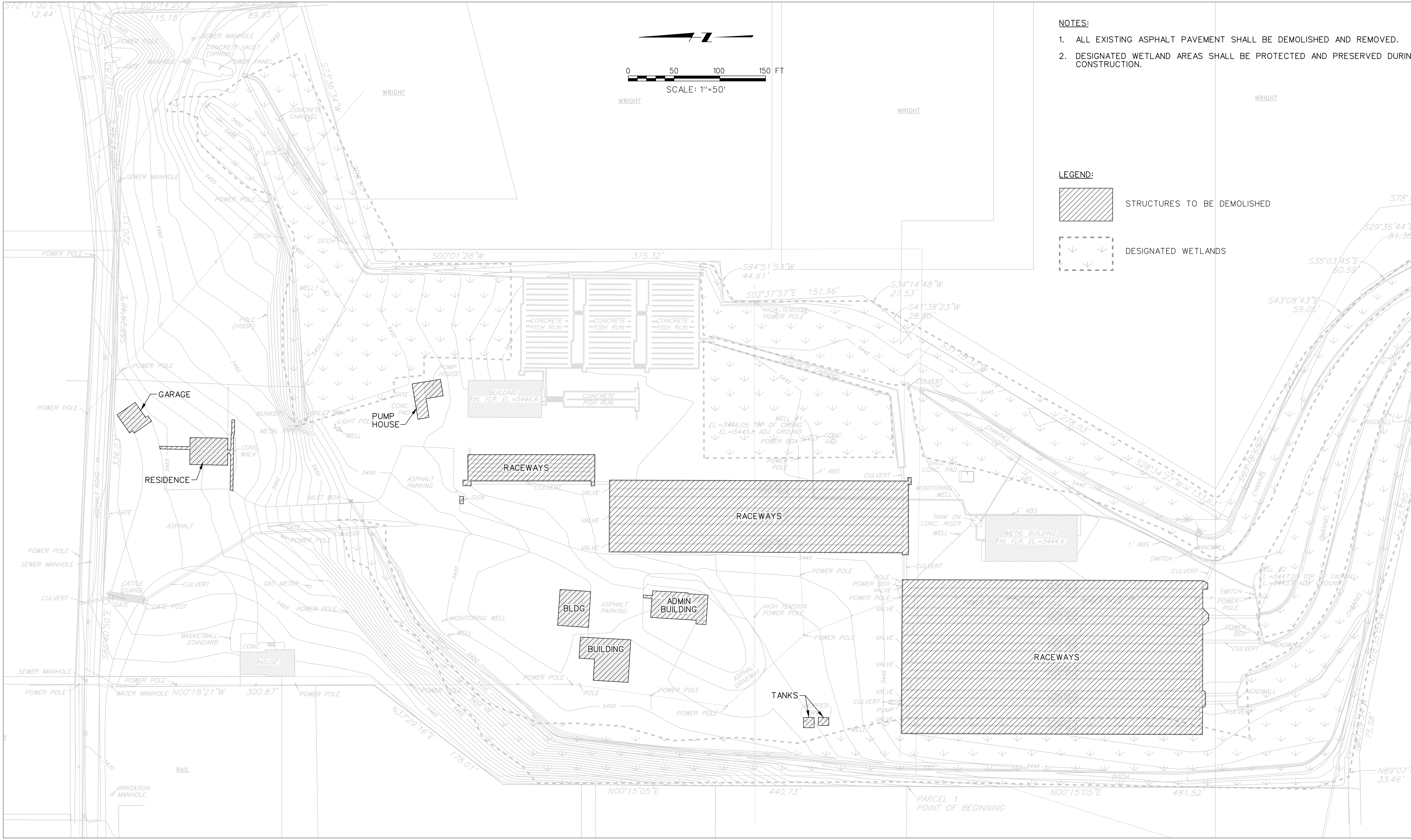

Midway State Fish Hatchery
Site Demolition Plan
Figure 4-4

MWH

house would need to be removed to make room for the new hatchery building. However, the residence in question is old, reportedly in poor condition and, according to the DWR staff, will need to be replaced within a few years. This site would only require initial well system pumping and all reuse water can be returned to the raceways by gravity flow avoiding the necessity to repump that water.

An analysis (MWH February 3, 2005) of the lower-upper hatchery building indicates that the fill requirement for locating the hatchery building to allow gravity flow would be unrealistic to provide flow by gravity. Under the best conditions, the hatchery floor would have to be 11.4 ft to 8.5 ft higher than the base of the raceway to discharge into a LHO at the head end of raceway series 100 or 200 or a pump system would need to be provided. While the pump capital and operating cost to lift the reuse water into the raceway is not excessive, DWR made the decision to utilize the single pumping lift option, and locate the hatchery building at the upper-upper site.

As shown in Figure 4-2, the preliminary selected site layout includes the outline of the jurisdictional wetlands in relationship to the proposed facilities. As indicated, intrusion into wetlands is limited, less than 0.10 acres, near the southwest corner of the raceways. This area would be used to provide access for larger vehicles at the end of the raceway. During design, we would attempt to eliminate or reduce this limited disturbance of the wetlands.

We would anticipate that the exterior of the hatchery building would be configured similar to Kamas and Fountain Green Hatcheries. The area around the building and the access way and parking areas where vehicles would operate would all be asphalt paved.

The south side of the building would be configured to provide a limited visitor experience without entering the building. This would include a viewing area into the early rearing room, and interpretative signage. Parking, except for handicapped, would be at a designated Parking Area in the lower-upper area (Figure 4-2). However, since the direction is to enclose the raceway building walls in metal panels, viewing the raceway area would be at the discretion of the staff to conduct tours for interested public. The hatchery building would include separate exterior accessible restrooms for men and women.

At staff direction, we have not shown any dedicated spots for temporary trailer hook-ups (level pad, power, water, sewer, etc.) these can be included in design, if requested.

4.2.3 Degasser. A single combination degassing tower, hatchery building oxygenation and head tank structure would be provided near the southeast corner of the hatchery building. The tower would consist of a concrete structure with a stainless steel packed column degasser containing ¾ to 1-inch plastic media. A sidestream oxygen injection system will be provided for the hatchery building water. Space would be provided for a future UV disinfection system as a contingency. The facility would be enclosed by ½ inch fencing and have a cover to prevent introduction of pathogen by birds or other animals. The water not used in the hatchery building would overflow in a separate pipe from the hatchery for gravity delivery to the raceways. It would also be possible to direct excess first pass water to the 100 series raceways and direct reuse flow to the 200 series raceways. As discussed with DWR, the degassed hatchery building water will be provided with the option to inject oxygen. The proposed system would use an eductor to inject a concentrated gas/water solution into the hatchery building water supply. Figure 4-5 provides a schematic representation of the proposed degasser/head tank/oxygenation system.

4.2.4 Residence. The new residence would be similar to the Fountain Green houses. The unit would be a three bedroom, two bath, 2-car garage, single story, stucco or wood sided house. The gross square footage of the main floor (including garage) would be approximately 1,500-1,600 ft^2. The new residence would be located in the lower-upper area east of the parking area near the existing abandoned treatment facility. As shown on Figure 4-2, the home would be moved somewhat to the north as required to avoid interferences with wetland areas and to provide separation with the old hatchery building. However, the area to the immediate east of the proposed location are wetlands and need to be avoided.

Several issues exist with this new residence. Since the site may be underlayed by poor quality wet soils, it would be necessary to elevate the main floor to be able to construct a basement (similar to the newer existing home (Photo 4-2), if a basement was required. The only other location considered for the resident was north of the existing hatchery home but was determined to be too close to the neighboring private home (Photo 4-3) and was eliminated for additional consideration by DWR. The construction of the existing new home was, according to staff reports, controversial with the owner of the home on the private property. A new adjacent residence may provoke additional controversy and will require careful consideration in terms of fencing, screening, etc.

Photo 4-2
Existing Newer Residence

Photo 4-3
Property Line

The two residences are on the City of Midway water and wastewater system. We will need to have the City's concurrence that the new home (replacement to the old home) and the limited hatchery building utility needs (3 restrooms and two sinks and volunteer area) can be accommodated by the City utility system.

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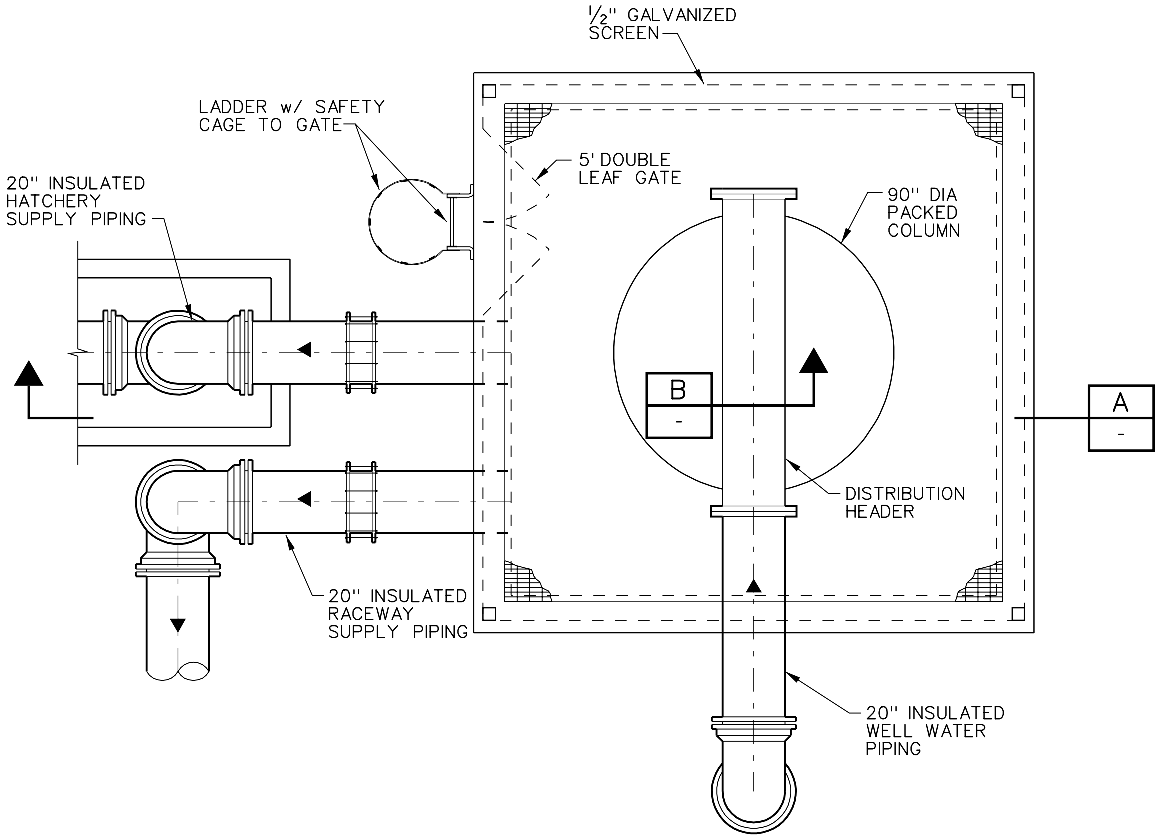
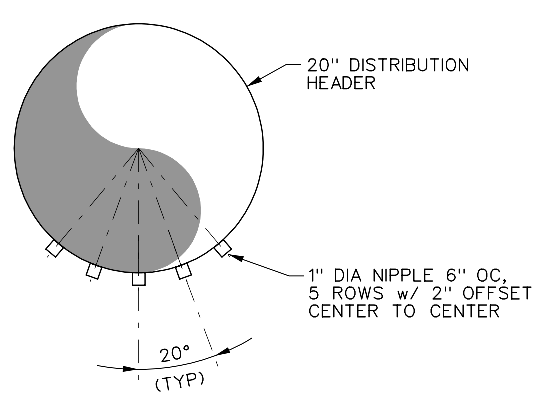
NOTES:

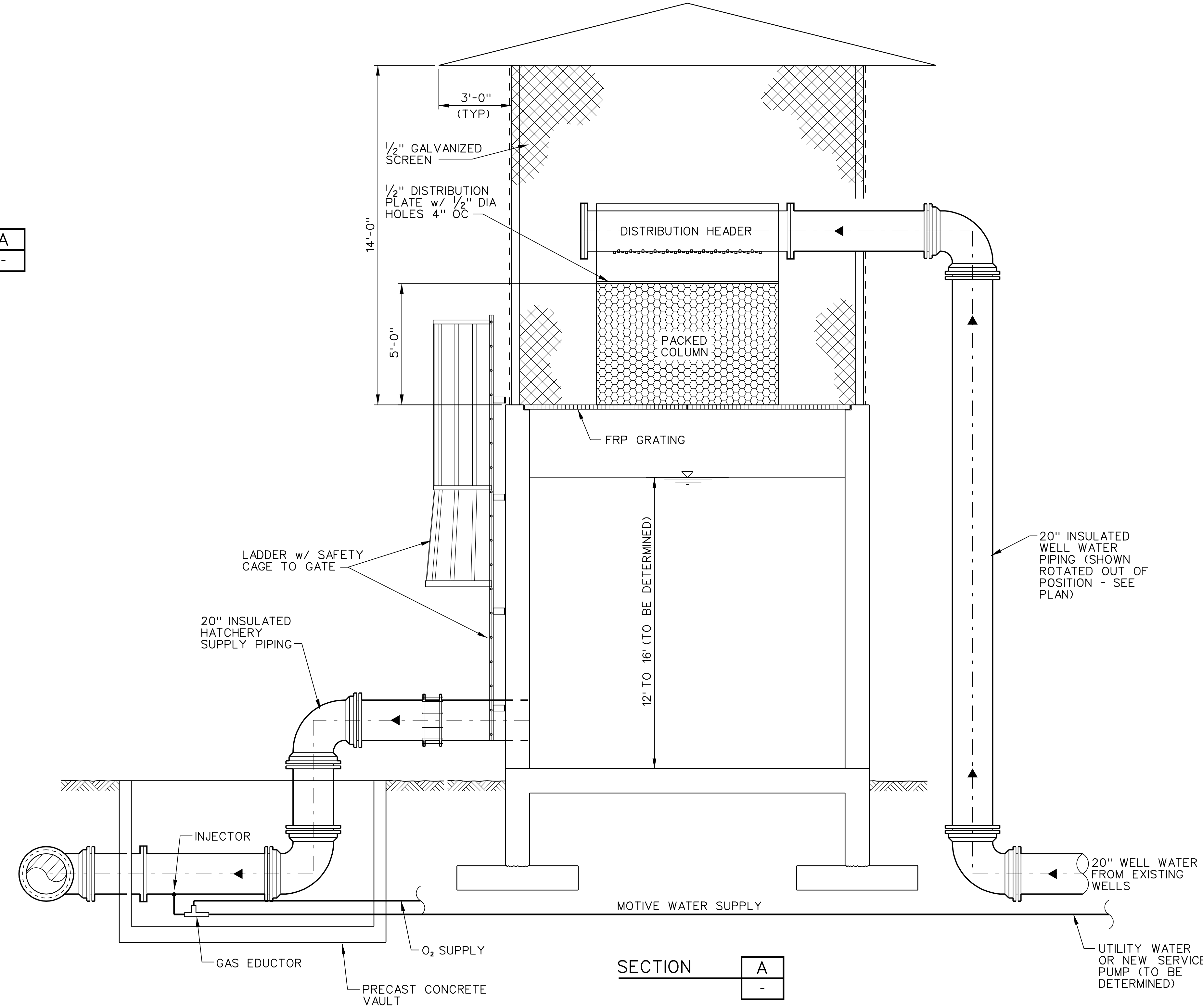
1. ALL METAL IN CONTACT WITH PROCESS WATER SHALL BE 316 STAINLESS STEEL.



NEW HATCHERY DEGAS AND HEAD BOX STRUCTURE PLAN



SECTION B



SECTION A

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Midway State Fish Hatchery
Degas and Headbox Structure
Figure 4-5

4.3 Water Supply and Delivery System

4.3.1 Well Water System. The well water system developed in 2003 by DWR is intended to provide a disease-free source of water suitable for effective rearing of salmonids. As discussed in Section 1, the DWR installed three wells that were finished within a confined geologic layer of protected low permeability in order to maintain a disease-free water supply. Based upon well testing by Mayo (2005), the three wells can be expected to produce a maximum of approximately 3,700 gpm. Two of the wells are complete and currently operable. The third well requires its pump to be connected to a power source. Appendix B provides the pump curves for the three wells. Based upon the available information, the wells have the following installed characteristics:

Well	Est. Combined Pump Production	Motor HP	Diameter	Depth
PW-1	800	15	16 in.	386 ft
PW-2	1,200	25	16 in.	367 ft
PW-3	1,700	40	16 in.	390 ft

The pumps and pumping rates were selected to prevent drawdown in the wells in excess of approximately 33 feet in order to avoid reversing the existing artesian upward gradient from the lower confined aquifer.

Based upon the results of our fish production model and discussion with DWR, it is unlikely that the water requirement for the hatchery will ever be less than 1,500 gpm once the facility is in full production. The majority of the time the expected flow will be in excess of 2,000 gpm. We have proposed that wells PW-1 and PW-2 be configured to pump to the degassing facility using constant speed motors. PW-3 would be modified to operate using a variable frequency drive (VFD) device that would allow the staff to manually adjust the flow using a single combined flowmeter at the degassing structure. This would allow the DWR to select a precise flow and reduce energy cost. Assuming that PW-3 would operate annually at 50 percent capacity, the addition of a VFD could save approximately $12,000 in annual operating cost based upon the installed horsepower. That would result in a one year (approximate) pay back on the capital cost of the VFD. In addition, the use of the programmable controller to operate VFD would reduce the standby power cost and should allow a single emergency generator to service all three wells since the starting power demand under emergency conditions could be reduced using the VFD on PW-3.

The three wells would be plumbed into a single pipeline delivering water to the degassing structure near the hatchery building. The diameter of the piping would be selected to match the gaining flow from each well. Each well would be provided with an check valve to prevent backflow and reduce the need to control individual flow rates and pressures.

It would be possible to automate the system and have the level in the head tank controlled by the VFD motor operation. This could be designed to allow the head tank to maintain a constant head (volume and flow) regardless of water use. This is a minor component of instrumentation and DWR would need to determine if it would be a desirable element for the project.

Well water supplied to the degasser would either be oxygenated and sent to the hatchery building for incubation and early rearing or would flow along with hatchery water to the raceway rearing unit. As directed by DWR, reuse water would be directed to the two head end raceway series (100 and 200) only. Figure 4-6 provides a preliminary site piping plan for the new facilities.

A utility water system, using the disease-free well water, will be included in the building to provide a washdown and cleanup water supply. The pipe trench will be sloped to a sump and a sump drain provided; however, all process water would be contained in pipes.

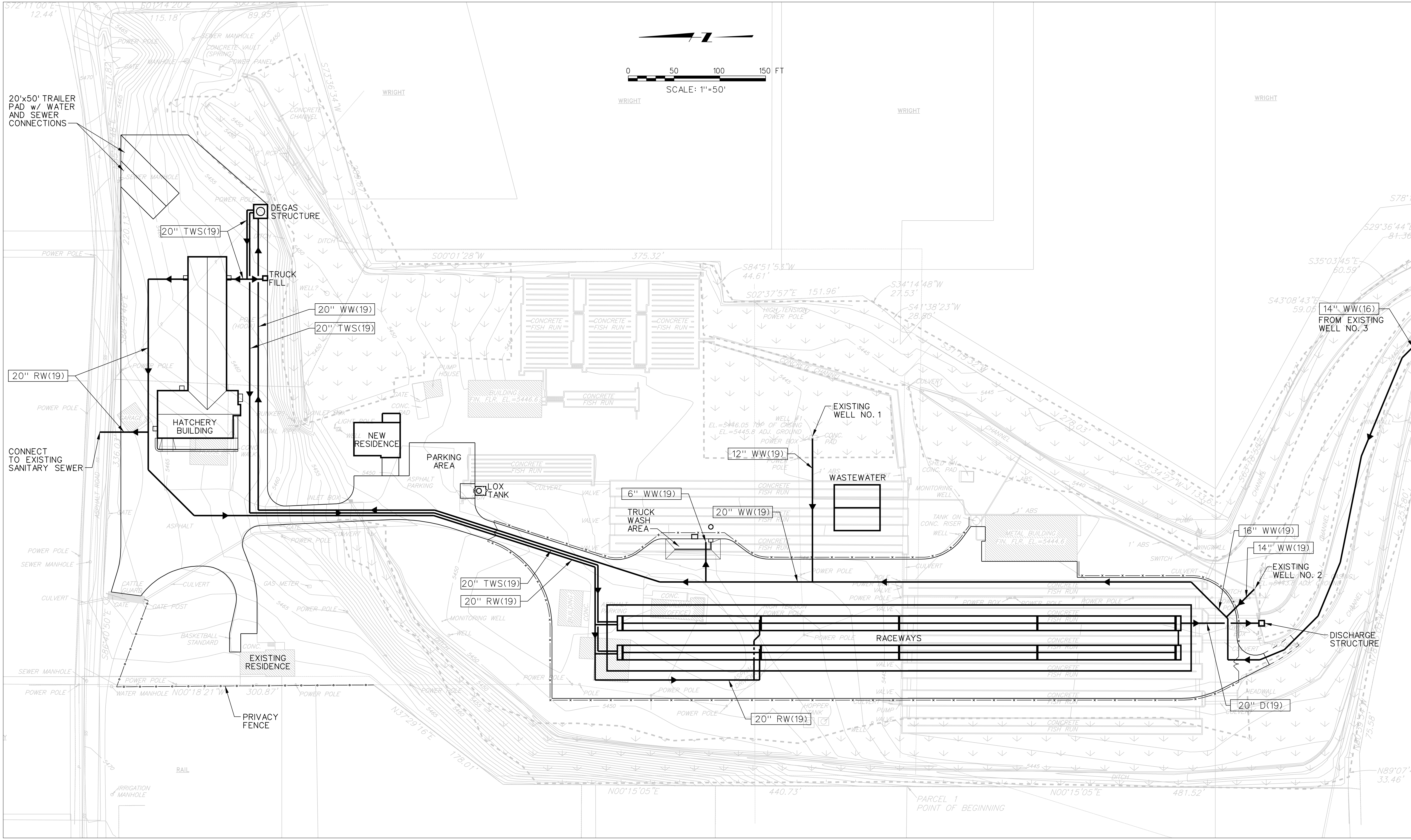
Water delivery from the head tank can be provided to the rearing troughs either overhead or from the pipe trench. We would recommend establishing the elevation of the degassing tank to allow for overhead deliver for all rearing water. This improves the hydraulics of the system and allows for future flexibility.

4.3.2 Low Head Oxygenators. Low head oxygenators (LHO) will be used at each raceway to supersaturate the supply rearing water (110% target). The LHOs in the 100 series raceways will be pipe fed and the subsequent units will be overflow weir supplied from preceding raceway discharge. LHO units will be constructed of stainless steel. The LHOs will be provided gaseous oxygen from a central liquid oxygen (LOX) supply tank. The cryogenic oxygen storage tank and vaporizer can be purchased or leased depending upon DWR direction. The LOX storage area will be near the large parking area to allow easy access by the delivery truck. The tank and appurtenances will be fenced to protect both the equipment and visitors and be designed to OSHA and industry standards.

4.4 Wastewater Management

Solids are non-soluble materials introduced into a hatchery-rearing unit in two ways – through natural or introduced conditions as part of the water supply (sands, silts, etc.) or as a result of the aquaculture operations in the form of fish food and metabolic waste. Natural or introduced conditions can include heavy precipitation runoff, discharge from dams and other holding structures, emergency conditions (e.g., landslides, streambank destabilization, and well failure), poorly designed well screens and a variety of other occurrences. However, since most hatcheries are specifically sited for their ability to use a high-quality water supply, the potential for this type of solids introduction is relatively low, especially at Midway where the well source should contain very few solids.

The major source of solids in most aquaculture operations is from the feed used to rear the fish. Depending on the type and formulation of the feed and how it is applied, the characteristic of the solid will vary. Feed is applied to the rearing unit as a scheduled manual or automatic feedings or through the use of demand feeders. The feed is then ingested by the fish or carried through the system as waste solids. Fish digest the ingested feed and waste products are returned to the water as a soluble component (metabolic waste produces ammonia, orthophosphate, etc.) or as



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Midway State Fish Hatchery
Water Supply Piping Plan
Figure 4-6

unprocessed solids that include non-digestible or partially digestible binders in the feed and undigested feed.

The solids returned to the water as digestion waste products will be generally lower in nitrogen (proteins), phosphorous and other nutrients than undigested food, but can still contain a significant percentage of the original values. If allowed to remain in the rearing units, this material can partially solubilize and cause a number of problems. They can include:

1) Increased oxygen demand as the material continues to break down biologically (biological oxygen demand – BOD).

2) Impacts on fish health as the waste solids can promote bacteria and fungal growth in the rearing units that may interfere with growth and viability of fish.

3) Release of nutrients (primarily nitrogen and phosphorous) into the rearing water, which will eventually be discharged to the receiving stream creating environmental and regulatory problems.

4) Noxious and problematic growths of fungus and algae that feed on nutrients in the unutilized and waste feed. These can accumulate within the rearing units and create secondary problems regarding maintenance and eventually fish health.

5) Aesthetics, especially as perceived by visitors.

Generally, it should be the goal of a well-operated hatchery to reduce production of waste solids and to remove solids as rapidly as possible to avoid the further breakdown of the material into small units and/or its solubilization. Since the Midway Fish Hatchery raceways will be covered and not exposed to direct sunlight, photosynthetic growth and accumulation will be minimal.

Solids in a rearing unit will either sink to the bottom or be washed through with the water flow. Water velocities (flow) in a raceway or longitudinal troughs are typically low and will not promote the scouring of settled solids through the system. As fish density increases and the size and activity (movement) of the fish intensifies, the movement of solids through the unit will improve.

The following specific objectives guide solids management in hatchery units:

1) Minimization of solids and solids by-products
2) Movement of solids through the rearing units
3) Collection and rapid removal of solids
4) Processing and handling of collected solids
5) Disposal of solids
6) Impact of solids management on receiving water quality.

These objectives are further discussed in the following paragraphs.

4.5 Objectives of Solids Hatchery Management

4.5.1 Minimization of Solids and Solids By-Products. Nutritional studies are a major element of fish research. A major goal of fishery science and commercial feed producers is formulating effective feeds that can be readily digested to provide the highest growth potential. The higher the effective utilization of feed, the lower the amount of solids generated.

Effective application and use of feed is also critical to successful, cost-effective aquaculture. Feed wasted through the system increases the operational, feeding and waste removal costs. Recent innovations in preparing and formulating feed has yielded highly effective, floating, pelletized products that remain in the water column longer (improving consumption) and reducing waste. While some fish culturists believe sinking foods may encourage more natural feeding patterns, commercially available floating (or partially floating) foods should be considered to improve utilization and reduce solids and by-products of food and metabolic waste.

4.5.2 Movement of Solids Through the Rearing Unit. Typically solids that settle out in rearing units are brushed along the bottom to a collection point at the end of the unit. This may be done daily or at longer intervals, depending on the feeding schedule, available manpower and hatchery procedures. While this manual procedure effectively removes solids from the bottom of raceways and troughs, it tends to re-suspend solids, washing-them through to the next unit (serial reuse) or into the receiving stream or effluent ponds. If the cleaning process is only intermittent, solids can build up and begin to breakdown biologically, releasing soluble nutrients into the flow. The DWR baffled raceway system reduces the handling and breakdown and resuspension of solids and improves overall maintenance while reducing labor.

4.5.3 Collection and Rapid Removal of Solids. Rearing-unit solids need to be separated from the water flow as quickly as possible to avoid solubilization and degradation. This can be accomplished through filtration and sedimentation, which are relatively simple separation methods. Biological treatment processes that remove pollutants in the form of soluble nutrients simply convert soluble organic material to a solid form (biomass) for physical removal. Proper hatchery management quickly removes all solids in an intact state because they are more difficult to separate and remove if they are degraded or mechanically macerated by physical handling.

The two approaches to rapid removal involve 1) settling and removal from the rearing unit, and 2) maintaining the solids suspended in the water column and removing them in the total flow of the system. Due to the volume of water involved and the very dilute characteristics, removal and handling of raceway settled solids is the method preferred by DWR.

Positive removal of solids using a microscreen or filters is also becoming a popular alternative. These systems isolate solids from the water flow and remove them in a concentrated form that can be disposed of in a sanitary landfill or through land application. Microscreens in the 60- to 90-micron range typically remove at least 90% of the total solids in a decanted solid flow or in the rearing-unit effluent flow.

Microscreens pass water from the outside to the inside of the screen through a screen installed over a rotary drum. As dilute solids (1-2%) are collected and build up on the drum screen, the flow is reduced and a differential pressure builds up across the drum casing. This causes solid removal sprays to activate, removing the solids to a collection trough. The collected solids (10 to 12%) are then deposited in a tank for eventual disposal by truck or further dewatered to reduce volume for disposal.

Microscreens are effective, require significantly less land than waste stabilization ponds, use little energy, and are relatively simple to operate. The disadvantage is that solids must be disposed of at an appropriate site and the units have hydraulic limitation and have not proven to be effective for some batch hatchery clearing operation without the addition of a storage or flow equalization tank.

Two approaches can be taken to microscreening:

- Screen only streams of water already heavy in solids, such as the water/solids mix vacuumed from the quiescent areas of the baffled raceways.
- Screen the entire flow, using rearing units that don't separate solids internally or that are swept frequently. In the case of baffled raceways, the solids settling area can be reduced and that space can be used for rearing fish.

Another commercial option for small volumes of settled solids is to use a bag filter dewatering system. Marketed by several manufacturers, these systems inject and mix a dewatering polymer into collected solids (raceway cleaning water) then deposit the wet solids in specially fabricated bags. The water drains through the porous bag leaving a solids residue in the bag. The filtrate is collected and returned to the receiving water or otherwise disposed of onsite. The bags continue to gravity dewater and are reported to achieve as high as 50 percent solids over time. The filled bags are disposed of at a landfill or applied to land as a soil amendment.

The commercial equipment is automatic in terms of polymer addition and solids distribution to the filter bags. The systems can be equipped with multiple bags that will operate until a bag or bags are full and then shutdown (alarm condition). Given the rapid raceway cleaning system used by DWR hatcheries, a small storage tank (8,000 gallons) and transfer pump would be required. The advantage of this system would be the small size (footprint), ease of operation and final disposal of collected solids. It is similar to what DWR has experimentally used for raceway solids handling and dewatering but developed as a commercial system.

A third option would be to discharge raceway cleaning flow to a settling and/or drying pond. This would be similar to the system used at the DWR Logan Research Station. The Midway Fish Hatchery would generate significantly more solids than the Logan Research Center and the settling basins would need to be designed to both decant settled water and dry the settled material. The structure will require a cover to avoid precipitation and given the climate in the Midway area, solids drying may be difficult to maintain. Also settling/drying beds are subject to odors, and other problems (flies, vector species, birds, etc.) and the dewatered solids must be collected and handled for final disposal.

4.5.4 Disposal of Solids. Liquid (untreated) solids (typically 2 to 5% solids) can be disposed of on fallow land, pasture or on agricultural lands by spraying the solids directly from a disposal truck or fixed and portable spraying systems or by pumping them into a pond for subsequent land application. Both systems are used extensively for municipal sludge and both would work well for hatcheries. We would anticipate that it may be necessary to use a liquid land application disposal method (or a landfill) for solids disposed of to a settling/drying basin give the climate in the Midway area.

During long periods of frozen ground or wet field conditions it may be preferable to dewater solids to a cake form (20 to 25% solids) that could be disposed of at a landfill or stored for land disposal during warmer months. Solids could be concentrated using a small plate and frame filter press, a gravity-belt filter, or a simple pan or bag filter (as discussed) if disposal volume is small enough. As discussed, DWR has experimented and had success adding filter aides (polymers) to raw solids and using an improvised cloth filter system for the gravity dewatering of solids to remove water. This reduces both the volume to be handled and the cost of landfill disposal which is typically based upon a dollar per weight unit. The availability of commercial equipment for this purpose makes this option attractive.

For the Midway Fish Hatchery we will continue to investigate the use of both settling/drying beds and bag filters before making a final recommendation.

4.6 Impact of Solids Management on Receiving Water Quality

Solids are the major contributing factor to water quality degradation from hatcheries. Solids contribute little metabolic ammonia, which is soluble and excreted from the fish's gills. However, unused fish food can contain significant levels of protein that can be metabolized by bacteria into ammonia and other nitrogen waste products. Even more important for phosphorous-limited receiving waters is the discharge of total and orthophosphorus that remains in solids and is solubilized over time. In areas around the nation, control of phosphorous discharge by fish hatcheries has become an important issue.

While the relatively recent availability of low-phosphorous feeds has helped reduce concentrations of phosphorous released into the environment, active management of waste solids can further that objective.

The relatively small increase in available phosphorous caused by hatchery discharges compared to municipal wastewater discharges (without phosphorous removal) is minor. However, in phosphorous-rich areas, increased phosphorous levels can stimulate eutrophication and algae growth, which could lower dissolved oxygen, increase temperatures, cause taste and odor problems, and impact other aquatic life.

As proposed, the new Midway Hatchery building rearing tanks would have a solids drain pipeline separated from the reuse (overtopping) water in order to collect and dispose of accumulated solids. This wastewater would be sent directly to the waste handling facilities and not be co-mingled with the water sent to raceway reuse. Consequently two drain pipelines would be provided from the hatchery building to the lower-lower area.

As proposed, the raceways will be provided with hinged baffles that allow better control of water velocities in the raceways and movement of solids to the collection sumps. The solids collection sumps will be double screened to allow for a bulk head to be added for cleaning similar to the Kamas and Fountain Green Hatcheries. The drain line will include a standpipe that will act as both an emergency overflow and, when removed, drain solids from the collection sump.

Solids treatment and removal at the Kamas and Fountain Green Hatcheries has relied on microscreens. The microscreens filter out solids and the solids collected are wasted off the screens. In theory a large volume of water with a low concentration of solids is filtered (screened) to produce a smaller volume of water with higher concentration of solids. This type of equipment works well for constant hydraulic condition, it has proven to be somewhat problematic at Kamas and Fountain Green Hatcheries where, due to the method of solids collection and removal using a rapid sump drainage (rapid uncontrolled draining), the screen can be hydraulically overloaded and the units go into a bypass mode. Without an equalization tank, we would not recommend microscreens for Midway if this same solids removal approach is selected.

Another option is to provide settling basins (similar to the Logan Hatchery Experimental Station) and allow the solids to settle (with or without chemicals). The decant effluent is drained off and the solids are allowed to densify and/or dry and can then be removed as wet sludge (pumped) or, if dry enough, removed physically for disposal. As discussed, the DWR has been experimenting with a solids dewatering method where dewatering chemicals are added to the settled solids and the wet solids are pumped to a gravity filter and allowed to drain. The densified fish waste material is not regulated in the same manner as human related wastewater solids. It can be disposed of in any manner that does not create a nuisance or vector problem at a landfill or used as an agricultural soil amendment.

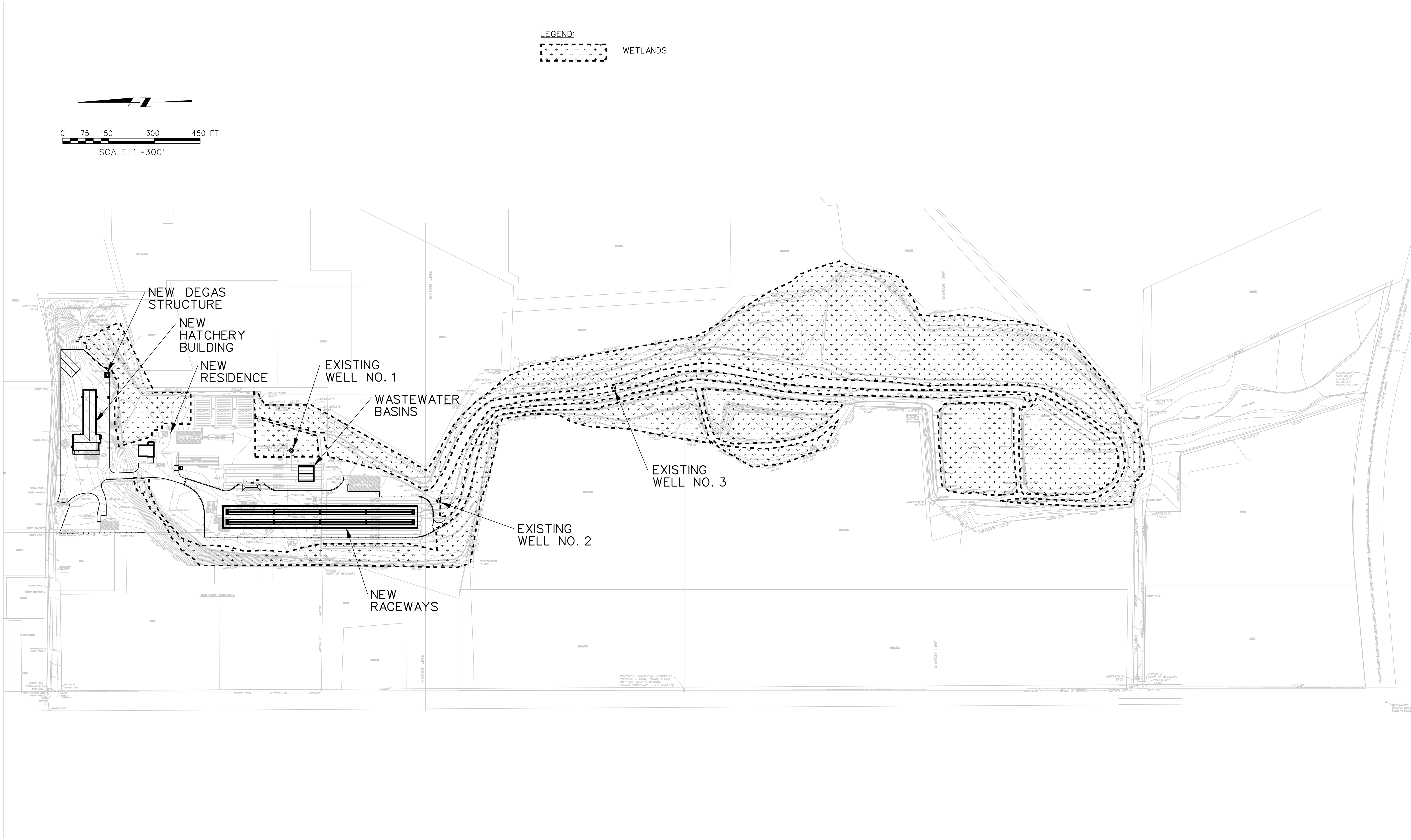
Based upon a 1:1 food to fish conversion ratio and 198,000 lb per year of fish production, we expect that the total dry solids produced would be in the 30,000 to 45,000 lbs dry solids per year based upon the following general relationship:

Suspended Solids	=	0.35 x Feed Provided
Solids Captured	=	40% to 60%

On an average day basis this equates to 80 to 125 lbs/day of dry solids or 313 to 450 gallons per day of 5.2 percent wet solids.

4.7 Effluent Disposal

The existing Midway Hatchery site is impacted by a significant wetland area. Figure 4-7 presents a recent (2006) mapping of the regulated wetlands on and surrounding the hatchery. Since the ponds are currently considered “waters of the nation” for wetland classification purposes, and must be maintained (not withstanding their past use and management for fish rearing and waste solids disposal), we would propose to use the ponds (Ponds 4 and 5) to discharge solids treatment (settling pond decant) effluent water. This would provide the opportunity for additional phosphorus and other nutrients and waste removal but may require a



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Midway State Fish Hatchery
Wetland Plan
Figure 4-7

second permitted discharge point. Raceway flow through water would be discharged through a separate pipeline to the point of discharge compliance, below Pond 5. The flow-through water should be of relatively high quality and would not significantly benefit by pond treatment since in a well operated system it should be low in both solids and nutrients.

4.8 Support and Infrastructure Facilities

4.8.1 Support Facilities. The existing hatchery has a significant support and infrastructure system in place. The residences are currently connected to the City of Midway domestic water and wastewater systems. The continued use and minor expansion of the use of these systems will need to be discussed and agreed upon by the City, maintaining this arrangement would be recommended. Providing onsite wastewater treatment and disposal would be complicated due to the very high groundwater on the site. A domestic water well could be developed for use at the hatchery, however, for the very small amount of additional domestic water the new hatchery would require (150-250 gpd±), a new well system does not appear to be warranted. The hatchery is currently supplied with natural gas for heating and to fuel the standby power generator. Figure 4-8 provides a "best estimate" of the existing buried piping and utility systems. These will need to be confirmed by the construction contractor.

The hatchery has a significant single three-phase power supply. The power company has not as yet been contacted, we would not anticipate that the power demand from the new facilities (primarily the well pump) would be an issue to the power provider.

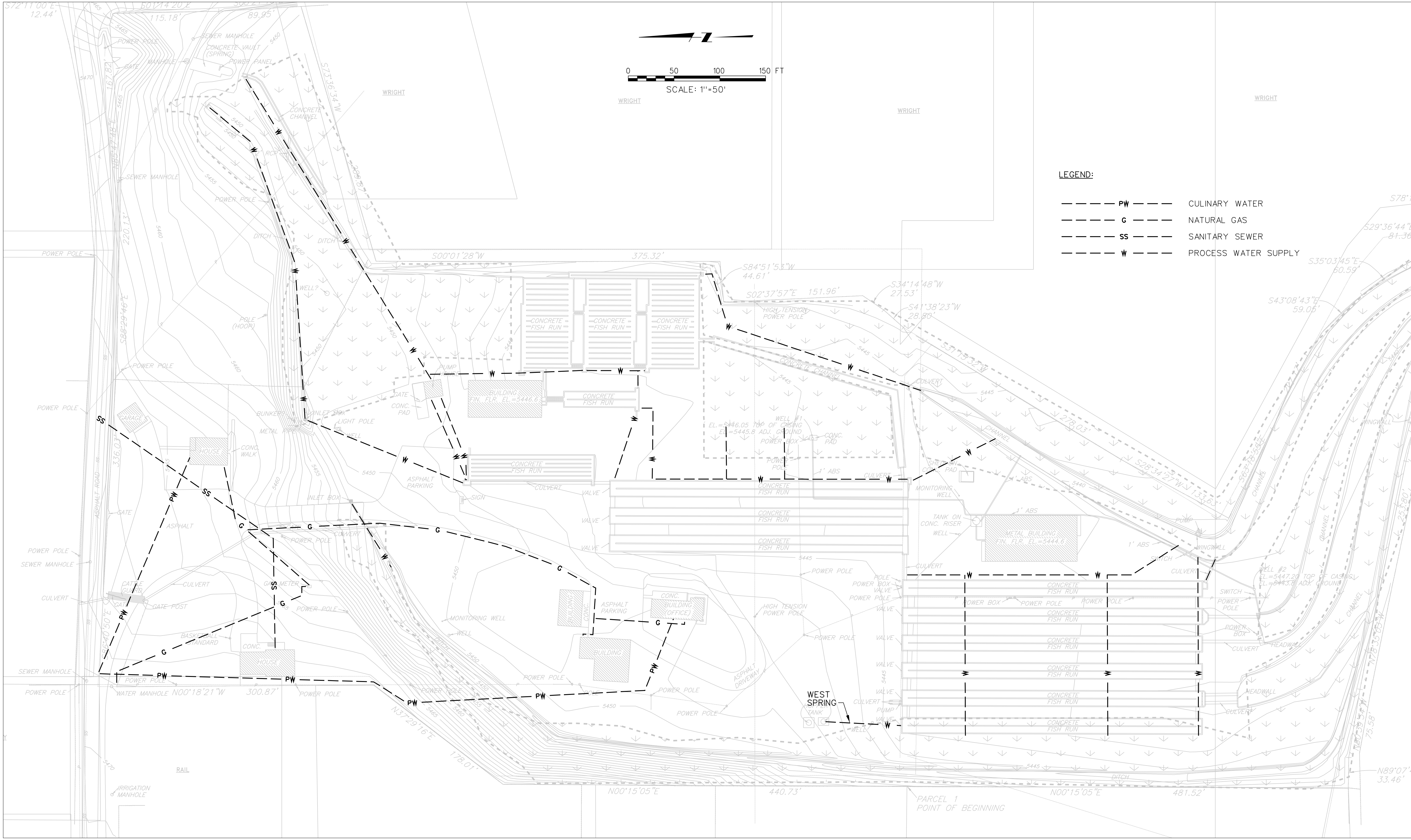
Of some concern is the large main power line that crosses the upper section of the area proposed from the new covered raceways. While this feature would not preclude construction coordination with the power company and care during construction will be required to avoid conflict with the large (45K volt) system.

Local communication (telephone, computer, Internet) facilities are currently available onsite and no problems connecting the new facilities to the communication system would be anticipated.

4.8.2 Demolition. As proposed (see Figure 4-4), all of the existing facilities at the Midway Hatchery would be removed (demolished and hauled away for disposal) with the exception of the following:

- new residence
- new metal building
- existing wells
- existing water and wastewater facilities
- existing power supply facilities
- existing "old" hatchery building and adjacent raceways

4.8.3 Access. We would recommend improving the existing entrance area to provide a new gate for security and adding a second developed access to the county road at the northeast corner of the property (near the existing spring box).



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Midway State Fish Hatchery
Existing Water Supply and Utility Plan
Figure 4-8

4.8.4 Drainage. The existing spring flow will need to be routed to the current drainage (see Figure 4-8). We would recommend that the spring head box be further investigated and that a closed pipe system be used to transport any potentially contaminated shallow groundwater and surface flow away from the new rearing facilities to avoid possible contamination.

Surface runoff, snow and snowmelt will need to be evaluated during design to ensure proper drainage is maintained. All runoff will need to be directed to natural surface water drainage without causing problems.

Subsurface drainage issues will need to be more fully developed during design. It is recognized that groundwater in the area is very close to the surface and may require carefully considered during design.

Section 5

SECTION 5

PROPOSED MIDWAY FISH HATCHERY DEVELOPMENT PLAN AND OPINION OF PROBABLE COST

5.0 SUMMARY OF NEW FACILITIES

The proposed renovation of the Midway Fish Hatchery would, from an operational standpoint, replace all of the historic facilities.

The contaminated spring water supply would be replaced by a new well supply system. A new hatchery building and indoor (early) rearing and incubation facilities would replace the old hatchery building, administration building, vehicle storage building and raceways. The old hatchery building and adjacent raceways would be maintained as a presumed historic resource and possible future visitors area, but all of the other older facilities will be demolished and removed.

The new metal building and the three new wells will be maintained and improved. The newer residence (south of the entrance area) will be maintained but the older home will be replaced with a new residence. Emergency power will be provided for all critical fish culture functions.

The existing outdoor raceways will be demolished and replaced with new covered units designed for ease of operation and to prevent possible disease contamination.

The new facility will be designed to provide a limited visitor experience. Open access to the rearing facilities (early rearing and raceways) will need to be controlled by DWR for disease management.

As discussed in Section 4, the new facilities will be similar in design to the Kamas, Fountain Green and Whiterocks (under construction) in terms of general appearance, quality and materials and operation. Improvements and recommendations by staff operating other DWR facilities were solicited earlier and many of these improvement modifications will be incorporated into the Midway Hatchery design.

Figure 3-2 provides the recommended site layout for the proposed improvements. Several options were considered during conceptual design and preparation of this Master Plan in terms of unit and facility size, configuration and layout, and siting of the facilities required to maintain the production program identified by DWR for the Midway Fish Hatchery. Based upon the direction provided by DWR staff as part of the planning workshop process, and the need to develop the improvements within the confines of the land currently controlled by the State of Utah, the proposed plan appears to meet the project objectives as discussed earlier in this Master Plan.

5.1 Opinion of Probable Capital Cost – Midway Fish Hatchery

Preparation of construction cost estimate for budgeting purposes has had a greater degree of uncertainty over the last two years than in the preceding ten-year period, due primarily to the cost of materials and petroleum products that affect all aspects of project implementation. International demand for construction steel, concrete, petroleum related products (i.e., plastic pipe, liner material, etc.) and fuels for construction equipment, labor and materials delivery and related activities have made projecting construction costs more than a few months ahead speculative at best.

For this project, we have an advantage due to the available cost information that can be derived from the recent similar projects that DWR has developed. These hatcheries have many of the same elements, located in similar locations, and are recent enough in several instances to provide a reasonable basis for projecting future costs for the Midway Fish Hatchery which we have assumed will be funded for construction starting in late 2006.

Table 5-1 provides a concept level opinion of capital cost for the Midway Fish Hatchery as discussed in previous Sections. This is a conceptual level budget estimate and should be assumed to have a range of accuracy of plus 35 to minus 30 percent. As the design is further developed and the details more fully understood and identified, the budget estimate can be refined and improved.

Based upon Table 5-1, the current conceptual capital cost of the Midway Hatchery would be $9.3 million.

5.2 Opinion of Operating Cost – Midway Fish hatchery

Annual operating cost estimates were limited to water supply and building energy cost and mechanical maintenance and waste solids management costs for this evaluation. We did not attempt to provide the fish rearing direct costs (feed, oxygen, etc.) since these are a function of DWR purchasing contracts, hatchery staff labor costs and staff support costs (housing, transportation, etc.). We did not include costs for fish delivery or planting. Table 5-2 provides our opinion of annual operating costs based upon the assumptions identified. This first year annual cost ($47,000) assumes a full year one cost in 2008 using a 3.5 percent inflation factor in 2006-2007.

TABLE 5-1

OPINION OF PROBABLE CAPITAL COST
MIDWAY FISH HATCHERY (Third Quarter 2006)

	Item	Unit	Unit Cost $	Total $
1	Building Civil/Excavation/Demolition	LS	200,000	200,000
2	Drainage	LS	110,000	110,000
3	Yard Piping Rearing	LS	200,000	200,000
4	Hatchery Building Structure (complete)	LS	1,300,000	1,300,000
5	Early Rearing Tanks	Each	3,000	165,000
6	Misc. Fish Rearing Equipment (indoor)	LS	10,000	10,000
7	Building Mechanical	LS	400,000	400,000
8	Building Electrical	LS	250,000	250,000
	(Building Subtotal)			**2,635,000**
9	Well Improvements	Each	5,500	16,500
10	Degasser/Head Tank (complete)	LS	350,000	350,000
11	Site Paving	LS	150,000	150,000
12	Site Landscaping (minor)	LS	10,000	10,000
13	Site Fencing	LF	10,000	10,000
14	Visitor Facilities (Interpretative)	LS	20,000	20,000
15	Site Lighting	LS	10,000	10,000
	(Hatchery Site Improvements Subtotal)			**566,500**
16	Raceway Units Structure	LS	650,000	650,000
17	Raceway Units Civil/Site	LS	700,000	700,000
18	Raceway Piping Mechanical	LS	175,000	175,000
19	Raceway LHO	Each	4,000	65,000
20	Raceway Lining	Ft^2	10	300,000
21	Raceway Electrical (including line realignment)	LS	60,000	60,000
22	Raceway Cover	LS	900,000	900,000
	(Raceway Subtotal)			**2,850,000**
23	Wastewater Treatment & Piping/Valves	LS	300,000	300,000
24	Effluent Piping & Valves/Filling	LS	130,000	130,000
25	Site electrical	LS	20,000	20,000
26	Site Utilities	LS	30,000	30,000
27	New Residence (complete)	LS	200,000	200,000
	Project Subtotal			**$6,732,000**
	Contractor Costs* @ 18%			1,212,000
	Contingency @ 20%			1,346,000
	TOTAL CAPITAL COST			**$9,280,000**

**Project Bonds, Supervision, OH/Profit*

TABLE 5-2

OPINION OF LIMITED ANNUAL OPERATION COSTS
MIDWAY FISH HATCHERY (2008)

	Item	Unit Cost	Units	Total Annual Cost $
1	Electrical Power	KWH	355,000	40,000
2	Mechanical replacement	LS	600	600
3	Solid Disposal	LS	3,500	3,500
4	Heating Building	LS	---	3,000
	Total First Year Annual			**$47,100**

Assumptions:

1) First Year 2008
2) Power Electrical @ $0.09 KWH 20% Efficiency
3) Mechanical Replacement 1% Annual
4) Solids Disposal @ Landfill $50/ton dry
5) Building Heating 150 days 65 degree F
6) Average Annual Pumping 2,500 gpm @ 70 feet

APPENDIX A

MODEL

APPENDIX B

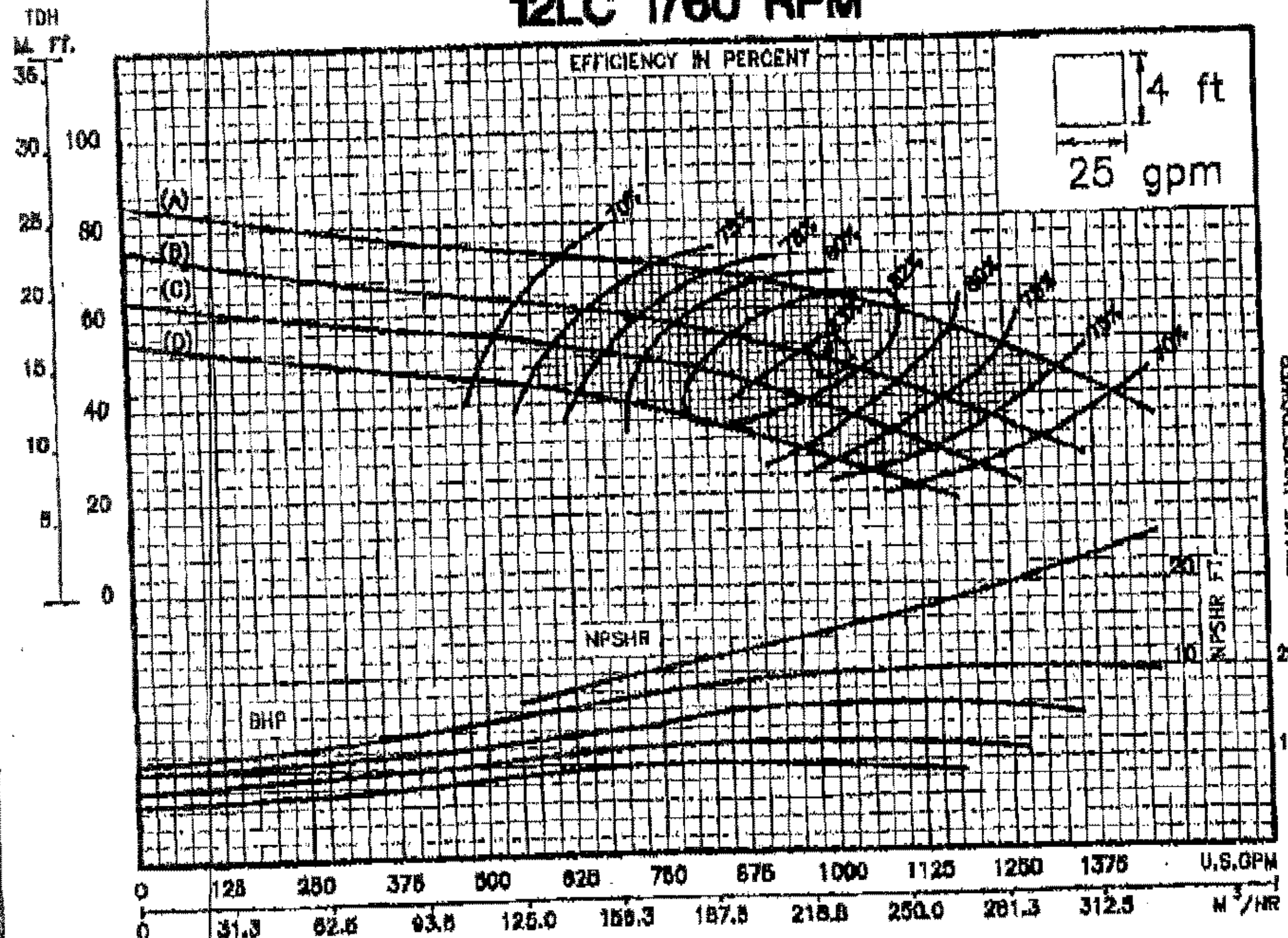
PUMP CURVES
MIDWAY FISH HATCHERY

J·LINE

TURBINE PUMP CURVE

JANUARY 1995

12LC 1760 RPM



CAPACITY

IMPELLER DATA

Impeller Number:	3778	TRIM:	(A) 9.375" X 21.5"
Material:	BRONZE		(B) 8.750" X 21.5"
Type:	CLOSED		(C) 8.250" X 21.5"
Thrust Factor:	K=10.50		(D) 7.750" X 21.5"
Eye Area:	20.10 sq. in.	Minimum submergence above eye of bottom impeller: 24 in.	
Weight:	15.50 lb.		

EFFICIENCY CORRECTION

Number of Bowls	1	2	3	4
Change as follows	-4	-2	-1	0

Change in efficiency may affect both head and horsepower.

BOWL DATA

Bowl Number	2952 C.I./ENAM.	
Bowl Dia.	11.563"max - 11.250"min	
Max. No. Stages	19	
One Stage Weight	340	lb
Add'l Stage Weight	100	lb
Std. Shaft Dia.	1.688	in
Std. Lateral	0.875	in
Discharge Size	8-8-10	in
Suction Size	8 - 10	in
Max. Sphere Size	0.625	in
Max. Operation P.S.I.	584 (special)	

Performance based on pumping clear, fresh water at a temperature not over 85° F., and free of gas, air or abrasives, and with bowls properly adjusted and submerged.

MERICAN MARSH PUMPS

PUMP DATA SHEET

American-Marsh Pumps

03/13/06

MERICAN WELL DRILLING / MIDWAY FISH

election list: —

earch Criteria:
Flow: 1450 US gpm
Head: 55 ft
Tolerance: — % of head

luid: Water
Temperature: 60 °F
SG: 1
Viscosity: 1.105 cP
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

IPSHa: — ft

dvanced Criteria:
Preferred Operating Area: —
Secondary Operating Point: —
Max temperature: — °F
Max suction pressure: — psi g
Max sphere size: — in
Max power: — bhp
Max suction specific speed: — (Nss)
Min trim: — % of max diameter
Min head rise: — % to shutoff

Curve Corrections: none

Catalog: WTRWRKS60-2005a vers 2.5a

Pump: 13MC.... (1 stages)
Type: 480_VRT-TURBINE
Synch speed: 1800 rpm
Speed: 1760 rpm
Dia: 9.625 in
Curve no.: 2899

Specific Speeds
Ns: 2810 Nss: 7621

Dimensions:
Suction: 8 in Discharge: 6 in

Vertical Turbine:
Bowl size: 12.125 in
Max lateral: 0.813 in
Thrust K factor: 7.9 lb/ft

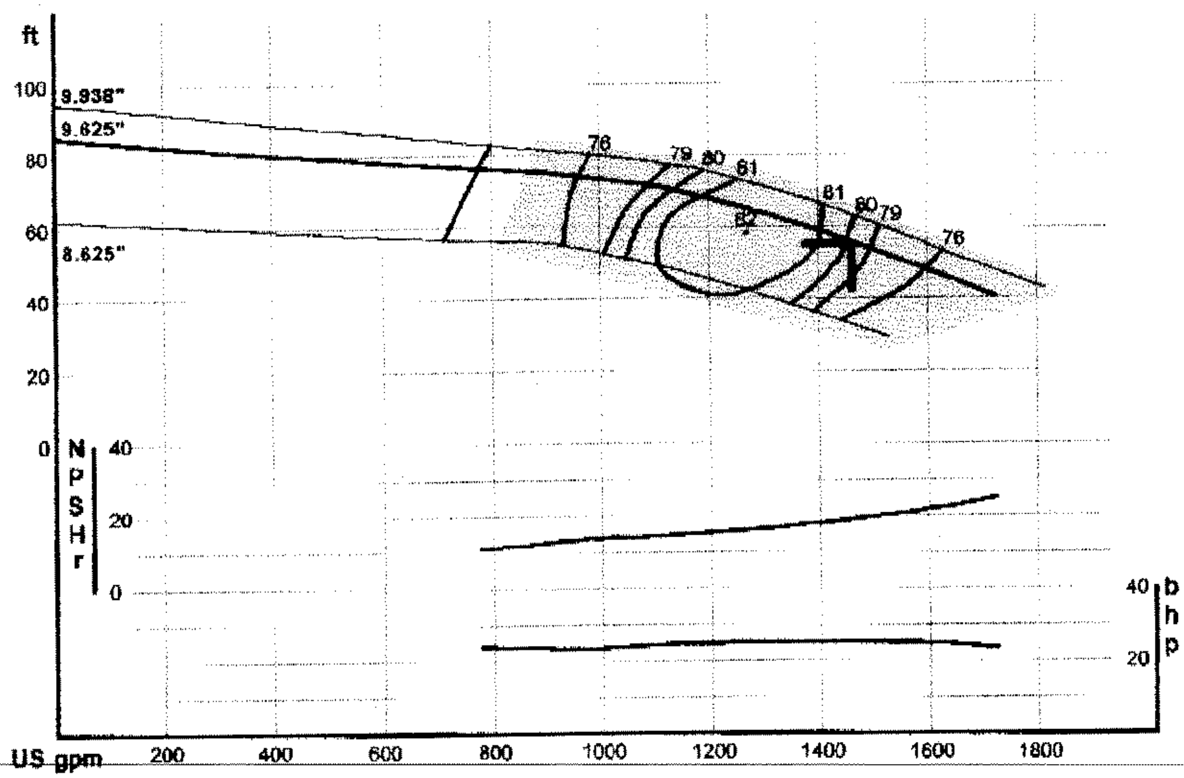
Pump Limits:
Temperature: 250 °F
Pressure: 584 psi g
Sphere size: 0.75 in
Power: 450 bhp

Motor: 25 hp
Speed: 1800
Frame: 284T
Standard: NEMA
Enclosure: ODP
Sizing criteria: sized by user

---- Data Point ----
Flow: 1450 US gpm
Head: 55.3 ft
Eff: 80%
Power: 25.3 bhp
NPSHr: 19 ft

-- Design Curve --
Shutoff Head: 85 ft
Shutoff dP: 36.7 psi
Min Flow: 773 US gpm
BEP: 82% eff
@ 1288 US gpm
NOL Pwr: 25.3 bhp
@ 1482 US gpm

-- Max Curve --
Max Pwr: 28.7 bhp
@ 1500 US gpm



Water Works vers 7.1

AMERICAN MARSH PUMPS

PUMP DATA SHEET

American-Marsh Pumps

03/13/06

AMERICAN WELL DRILLING / MIDWAY FISH

Selection list: —

Search Criteria:
Flow: 1700 US gpm
Head: 70 ft
Tolerance: — % of head

Fluid: Water
Temperature: 60 °F
SG: 1
Viscosity: 1.105 cP
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

NPSHa: — ft

Advanced Criteria:
Preferred Operating Area: —
Secondary Operating Point: —
Max temperature: — °F
Max suction pressure: — psi g
Max sphere size: — in
Max power: — bhp
Max suction specific speed: — (Nss)
Min trim: — % of max diameter
Min head rise: — % to shutoff

Curve Corrections: none

Catalog: WTRWRKS60-2005a vers 2.5a

Pump: 12XC. (2 stages)
Type: 480_VRT-TURBINE
Synch speed: 1800 rpm
Speed: 1760 rpm
Dia: 8.9375 in
Curve no.: 3380

Specific Speeds
Ns: 4139 Nss: 9017

Dimensions:
Suction: 8 in Discharge: 8 in

Vertical Turbine:
Bowl size: 11.25 in
Max lateral: 0.875 in
Thrust K factor: 18.2 lb/ft

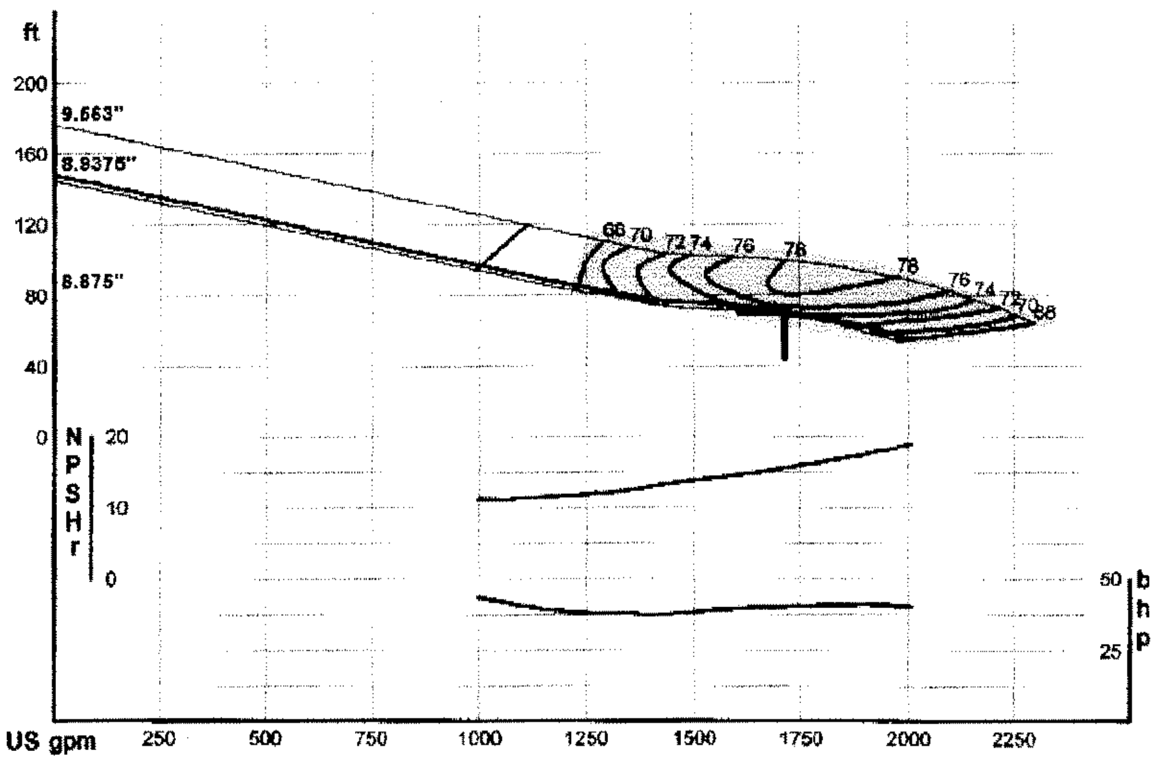
Pump Limits:
Temperature: 250 °F
Pressure: 584 psi g
Sphere size: 1 in
Power: 450 bhp

Motor: 40 hp
Speed: 1800
Frame: 324T
Standard: NEMA
Enclosure: ODP
Sizing criteria: sized by user

---- Data Point ----
Flow: 1700 US gpm
Head: 70.3 ft
Eff: 75%
Power: 40.4 bhp
NPSHr: 15.6 ft

-- Design Curve --
Shutoff Head: 147 ft
Shutoff dP: 63.7 psi
Min Flow: 992 US gpm
BEP: 75% eff
@ 1653 US gpm
NOL Pwr: 43.7 bhp
@ 992 US gpm

-- Max Curve --
Max Pwr: 57 bhp
@ 1960 US gpm



Water Works vers 7.1